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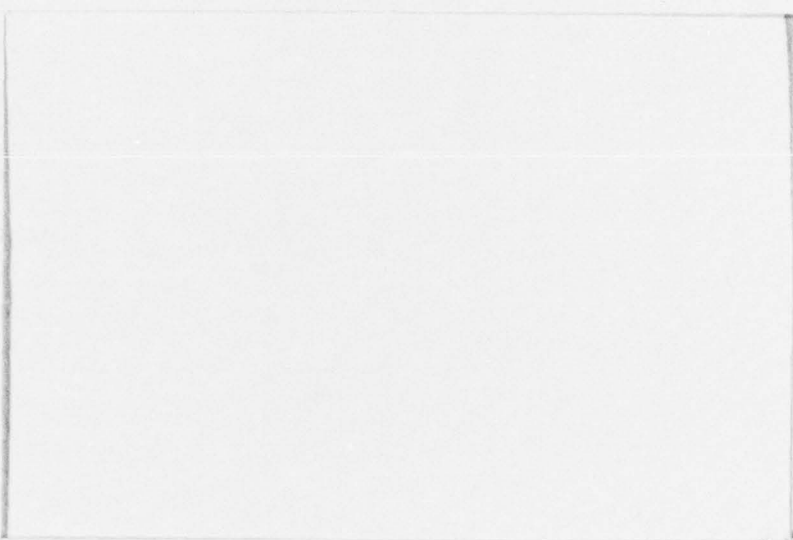
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Co-principal investigators :
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Bozena Henisz-Thompson Dostert
Frederick B./Thompson

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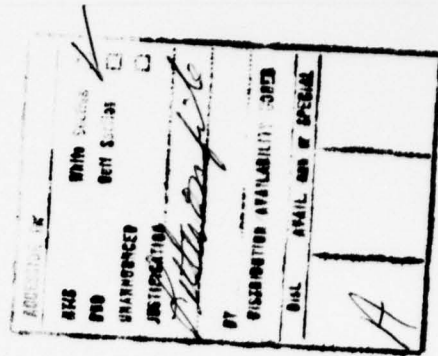
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INTRODUCTION

A. WHAT REL IS

A-1. REL (RAPIDLY EXTENSIBLE LANGUAGE SYSTEM) is a complete software system designed to facilitate natural and easy interaction between a user unskilled in programming with the computer. It is designed to support work with specialized data bases, and for this purpose it allows the user to manipulate the data bases by introducing changes and extensions in the data bases themselves. It also provides languages for communication which can be modified and extended by the user in facile and natural ways. The architecture of the system is fully described in Reference 3.

A-2. The principal language in the REL system is REL English, which is the subject of this book. It can generally be characterized as a technical dialect of natural English, with some restrictions on the constructions that can be used, and with some restrictions on colloquial usages. Elegance and fluency is certainly far less important here than usefulness and ease of adaptability to specialized technical jargons.

The ways of changing and extending a user's language and data to adapt it to his needs are extensively illustrated in the text.

Arithmetical capabilities are also illustrated.

A-3. An important part of the architecture of the system is that it allows the user to have several versions, either containing different data bases and languages or copies of his own data base and language. Having a backup copy and a working version is quite essential if one introduces changes and extensions in the language and data base.

How versions can be managed by the user is amply discussed and illustrated.

A-4. In order to make natural communication possible, response times are of great importance. A lot of attention has been devoted to this problem in the design of the system. The result is that we have achieved an average of three to four seconds response times for complex questions under good machine conditions, that is when the load is not very heavy.

B. THE PURPOSE AND ORGANIZATION OF THIS BOOK

B-1. This book is intended as an illustration of the capabilities of REL English. Examples are provided of typical sentences that can be used. But exhaustive coverage is clearly impossible.

It is recommended that the user become acquainted with the whole book on a preliminary basis before starting on specific examples. Although an attempt has been made at proceeding from simple to more complex sentences, this was not always possible. For instance, verbs are used early in the text, in sentences that appear quite simple, but the discussion of how verbs can be introduced by the user is later in the text.

B-2. The organization of the book is meant to facilitate working with a data base familiar to the user, first through providing examples of the types of questions and commands that can be used. And second, through providing means and examples of how a given data base and language can be modified and extended.

Also provided is an illustration of how an unfamiliar data base can be approached.

The protocols (i.e. interactions with the computer) which constitute the examples are all actual printouts from the terminal, and their quality unfortunately often leaves much to be desired.

Lines have been numbered in the protocol for easy reference to the discussions.

In some cases, mistakes in typing are corrected by the "^" character, as will easily be observed.

The "prompt" character (">"), which is typed in the computer, is sometimes missing in front of questions or commands. This is simply due to the manipulation of paper as the examples were being collected.

Portions of some pages are left blank, and some blank pages are provided to allow the user to take notes when working with the book.

C. THE STATUS OF THIS BOOK RELATIVE TO THE STATUS OF THE SYSTEM

This book represents the status of the system as of several months ago. In many cases, limitations in grammar that the user will encounter have already been eliminated. The same is true of bugs.

Some capabilities, for instance, the ways of introducing verbs, have been considerably extended.

The reason for this datedness is that we "froze" a version of the system at a certain point, that is no corrections or improvements could be introduced to it. This freezing was done in order to ensure that the book will correspond to the system which it describes.

At the same time, however, work progressed on another version of the system, which is now considerably advanced beyond the status of the system represented in the book.

I. AN REL SESSION

The initiation of an REL session, i.e. the access to the REL system, clearly depends on the particular computer system configuration that one is using. The same applies to the characteristics of the specific computer device which provides the access with respect to such capabilities as character or line deletion, error correction, or sending of the request.

As an example of the initiation of a session the logon procedure at Caltech is used in the protocol below. REL is operating at Caltech on the IBM 370/158 in time-sharing mode under TSO. The access is via Texas Instruments Silent 700 terminal through which all of the protocols were obtained.

```
LOGON PMN/REL SIZE(192)
PMN LOGON IN PROGRESS AT 13:18:48 ON JANUARY 18, 1978
NO BROADCAST MESSAGES
READY
5 REL NUM(3)
  PLEASE IDENTIFY YOURSELF.
  >RELSYS
    COMMAND LANGUAGE, PROCEED.
  >DIRECTORY
10 USER ID   VERSION NAME      EXTENTS  ENTERABLE  COPYABLE
      TOTAL
      ALLOCATED
      210
      150

      RELSYS  COMAIR          37      CREATOR   CREATOR
      NAVY    76      CREATOR   CREATOR
15      REL ENGLISH  27      CREATOR   CREATOR
      SYSTEM    7      CREATOR   CREATOR
      COMMAND    3      CREATOR   CREATOR
```

```

ENTER NAVY
PROCEED.
20>WHAT IS 2+3?
6
>EXIT
COMMAND LANGUAGE, PROCEED
>COPY TEST FROM REL ENGLISH
25 VERSION HAS BEEN COPIED
>ENTER TEST
PROCEED.
>WHAT IS 2+3?
5
30>EXIT
COMMAND LANGUAGE, PROCEED
>DELETE TEST
VERSION HAS BEEN DELETED.
>EXIT
35 PROCESSING COMPLETED, THANK YOU.
READY

```

The initial specific logon messages are not of general interest. Line 6, PLEASE IDENTIFY YOURSELF, is the first message from the REL system. Line 7 is an identification code of the user, which currently is RELSYS for all users at Caltech. The system responds with line 8, COMMAND LANGUAGE, PROCEED, at which point the user can start working. One of the options is to request the display of the directory which appears in the first two protocols (line 9 in the protocol above).

```

>DIRECTORY
USER ID  VERSION NAME  EXTENTS  ENTERABLE  COPYABLE
.....
TOTAL 210
ALLOCATED 206

RELSYS  NAVY-1  66  CREATOR  CREATOR
      COMAIR  37  NO ONE  ANYONE
      NAVY  66  NO ONE  ANYONE
      REL ENGLISH  27  NO ONE  ANYONE
      SYSTEM  7  CREATOR  CREATOR
      COMMAND  3  CREATOR  CREATOR

```

The directory shows what versions exist, how much space they occupy, and what their status is. Illustration of these points is found on page 117. It will be noticed here that more extents are allocated in the second protocol due to the inclusion of another version, NAVY-1.

When one is in the COMMAND LANGUAGE and if the display of the directory is not requested, one can enter an "enterable" version, or copy a "copyable" one, and/or delete one. The second protocol includes a new version that had been created by copying NAVY. When naming a new version, care should be taken to use a name that had not been assigned to some other version.

A sequence illustrating working with versions is included in the protocol below.

```

PLEASE IDENTIFY YOURSELF.
>RELSYS
COMMAND LANGUAGE, PROCEED.
>ENTER NAVY-1
5 PROCEED.
>WHO IS COMMANDER OF THE KITTYHAWK?
CAPT R. SPRUANCE

>EXIT
COMMAND LANGUAGE, PROCEED
10 >DELETE NAVY-1
VERSION HAS BEEN DELETED.
>COPY COMAIR-1 FROM COMAIR
VERSION HAS BEEN COPIED
>ENTER COMAIR-1
15 PROCEED.
>LOCKHEED IS THE MANUFACTURER OF HOW MANY AIRCRAFT?
9

>EXIT
COMMAND LANGUAGE, PROCEED
20 >DELETE COMAIR-1
VERSION HAS BEEN DELETED.
>EXIT
PROCESSING COMPLETED, THANK YOU.
READY

```

It will be noticed that the lines typed in by the user are preceded by the "prompt" character > which is supplied by the computer. It is important to remember to ENTER the version of one's choice, as illustrated in line 4, and to EXIT from it (line 8) when one has finished working with a particular version. One is then returned to COMMAND LANGUAGE (line 9) and can continue working with versions (lines 10, 12). Finally one must EXIT also from the COMMAND LANGUAGE when one intends to terminate an REL session.

It should be pointed out that the results of an REL session are automatically stored permanently, so that the contents will be present at the next session. If the user introduces or deletes versions, this status will be preserved. If changes are made in some versions or some definitions introduced, they will be available for future use.

II. QUERYING A FAMILIAR DATA BASE

A. GENERAL INFORMATION

A-1. SOME BASICS

The data base which is used in the examples in this book is one concerning 202 ships, naval and merchant, U.S. and foreign; and various items of information about them such as flag (indicating the country to which a ship belongs), destination, percent fuel, speed -- about 52 attributes in all. This data base is quite spotty, that is in the case of very many ships most of those items of information are missing. The ways in which a user can find out about the contents of a data base are described in Chapter V. In this section, it is assumed that the user is working with a data base whose contents are familiar to him.

Examples are given in this section of the typical interactions with a familiar data base. The types of interactions can be questions, requests, definitions, and data additions but in this section they are mostly questions and requests, or commands (such as LIST). They represent the type of interactions in English which are real in terms of semantics, that is they are meaningful with reference to the data base.

The questions or commands have to be complete sentences in grammatical English, terminated by a question mark or a period (as appropriate), and observing the comma punctuation. The answers, however, consist only of the information contained in the data base and are not English sentences. Spelling has to be normal English spelling unless different spelling is introduced by definition (page 93). The system does not correct spelling errors at this time.

A-2. DIAGNOSTIC MESSAGES

In general, the user will not find very many diagnostic messages. This is the result of a deliberate decision in system design. Good, truly helpful diagnostics are notoriously difficult to come by. That is one reason for the decision. A more important one is, however, that a serious, involved user would find numerous diagnostics -- often inappropriate and diagnosing in a lengthy manner a point quite obvious to the user -- more of a burden than a help. This is primarily because the user would be considerably slowed down in the work.

The decision, therefore, in system design was to concentrate on quick response time and to give one quick, short diagnostic -- the message EH? -- in cases when the user's input is not understandable to the system for a variety of reasons. These may range from a simple misspelling or an unintroduced vocabulary item to the system's inability to handle some grammatical or semantic difficulty. Hopefully, this quick diagnostic frees the user to explore, through further questions, the nature of the difficulty.

Some diagnostics are supplied, however, and these are discussed below. Other than EH? and WHAT?, their format is that of sentences or phrases which, it is hoped, are fairly understandable. The discussion will be illustrative rather than exhaustive in character.

Occasionally, in cases of ambiguity, double messages appear.

a. The Message EH?

This message appears whenever the user's input is not understandable -- which may be for a great variety of reasons. The user may even deliberately cause this message so as to, for instance, abandon ("kill") an input rather than obtain undesirable results -- or because of a misspelling as illustrated in the following example.

```
DEF:LONGEST "SHIP":SHIP WHOSE LEE
EH?
```

If the message occurs and the difficulty is not obvious, spelling should be checked first of all. Occasionally the difficulty may clear up if the sentence is simply repeated, for example when transmission line problems occur. Vocabulary items should be checked for their familiarity to the system. The sentence may have to be paraphrased into a different form or restated in a simpler form if the grammatical or semantic structure cannot be handled.

Some examples of problems that may cause the EH? message follow, but the user will quickly become familiar with others.

A vocabulary item such as U.S. may not be known while US is, for instance:

```
WHAT ARE 'U.S.' NAVAL VESSELS?
EH?
/WHAT ARE 'US' NAVAL VESSELS?
'THERE ARE '49 'LINES 'IN 'THIS 'ANSWER.' 'HOW 'MANY 'DO 'YOU 'WANT?
'RESPOND 'WITH "'ALL'", "'NONE'", 'OR 'A 'NUMBER.'
/3
'CONSTELLATION
'SARATOGA
'AMERICA
'KITTYHAWK
'JOHN 'F.' 'KENNEDY
```

In the following protocol several reasons for EH? occur.

```
>WHO IS THE COMMANDER OF THE KITTYHAWK?
EH?
>WHO IS THE COMMANDER OF THE KITTYHAWK?
CAPT R. SPRUANCE
5>IS THE THAT TO?
EH?
>IS CAPT. R SPRUANCE A COMMANDER?
EH?
>IS CAPT R. SPRUANCE A COMMANDER?
10 YES
>WHAT IS THE KITTY HAWK'S HOME PORT?
EH?
>WHAT IS THE KITTYHAWK'S HOME PORT?
MAYPORT
```

In line 1 COMMANDER is a misspelling. Line 5 is not a grammatical sentence. In line 7 there is a period after CAPT and one missing after R, while the vocabulary item has been entered as it appears in line 9. Similarly in line 11, KITTYHAWK is spelled with a space it should not have.

Another reason for the EH? message may be line length. If the input goes beyond the terminal's line length, problems will occur. To avoid that, hyphenation and/or continuation of the line should be used as illustrated in the protocol below.

b. The Message WHAT?

In some cases of semantic or data base problems this message will occur even though grammatically the sentence is understandable. The difficulty may be avoided by asking simpler questions. In the example below the WHAT? message occurs because no ship qualifies for an answer.

```
WHAT SHIP IN TG67.1 WHOSE ENDURANCE IS AT LEAST 70%
>HAS PERCENT FUEL NOT EQUAL TO 100?
WHAT?
```

c. The Messages INSUFFICIENT DATA, NONE, VACUOUS

These messages reflect lack of information in the data base. In the protocols below some examples of specific cases are shown which are fairly self-evident. There may be other cases which are not so clear, and further exploratory questions may be needed.

```
>LIST THE COMMANDER AND CARGO TYPE OF THE LOS ANGELES.
  INSUFFICIENT DATA.
>WHAT IS THE CARGO TYPE OF THE LOS ANGELES?
  NONE
5>WHAT IS THE DEPARTURE POINT OF THE LOS ANGELES?
  UNKNOWN
>WHO IS THE COMMANDER OF THE LOS ANGELES?
  CDR D. JONES
```


>WHAT IS THE READINESS, CALL SIGN, MAXIMUM CRUISING SPEED
10 >AND ENDURANCE OF EACH SHIP WHICH HAS MAYPORT AS DESTINATION?
INSUFFICIENT DATA.
>IS MAYPORT A DESTINATION?
NO

LIST THE CALL SIGN AND COMMANDER'S LINEAL FOR EACH SHIP WHOSE
15 >SPEED IS GREATER THAN 16 AND WHICH DEPARTED WASHINGTON;
INSUFFICIENT DATA.
>IS THERE A SHIP WHOSE SPEED IS GREATER THAN 16 AND WHICH
>DEPARTED WASHINGTON?
NO

20 >WHAT IS KNOWN ABOUT SHIPS THAT DEPARTED OSLO?
THERE ARE NONE.

>LIST THE CALL SIGN AND COMMANDER'S NAME FOR EACH SUBMARINE
>WHOSE SPEED IS GREATER THAN 15 AND WHICH DEPARTED NORFOLK;
NOUN RELATIVE CLAUSE PHRASE IS VACUOUS.
25 >ARE THERE ANY SUBMARINES WHICH DEPARTED NORFOLK?
YES
>ARE THERE ANY SUBMARINES WHOSE SPEED IS GREATER THAN 15?
NO

In line 2 the INSUFFICIENT DATA message is due to the fact that the cargo type of the Los Angeles is not in the data base, evidence for which is the NONE of line 4, even though the commander is known (line 8). In line 11 this message is due to the fact that Mayport is not a destination of ships (line 13). The situation is similar in lines 14-19.

The message NONE is self-explanatory in lines 4 and 21. There are, however, cases where this message may reflect the organization of the data base and appear where no direct relation exists between data items, even though the user may not be aware of this lack of connecting data. The message NONE may also appear with other messages in cases of ambiguous analyses.

Paraphrased, simple exploratory questions are the best ways to clarify such situations.

The message referring to VACUOUS in line 24 results from the fact that one of the relative clauses is indeed vacuous., i.e. has no referent in the data base (lines 27-28). Other messages including the term VACUOUS also exist, and may at times be inappropriate.

d. The Message PLEASE REPHRASE

In some cases of underlying complexities in processing or sources of ambiguity in analysis that may not be apparent on the surface we have chosen to request rephrasing rather than attempting to diagnose such deep problems.

HOW MANY SHIPS ARE THERE IN TU24.2.2?
PLEASE REPHRASE.
>WHAT IS THE NUMBER OF SHIPS IN TU24.2.2?
6

DOES ANY SHIP HAVE AS LITTLE AS 10 PERCENT FUEL?
PLEASE REPHRASE.
>IS THE PERCENT FUEL OF ANY SHIP AS LITTLE AS 10?
YES

ARE THE DESTINATION AND DEPARTURE POINT OF
>THE TARU EUROPEAN PORTS?
PLEASE REPHRASE.

e. The Message NOT IMPLEMENTED YET

Clear as this message is, in some cases it appears where implementation will not follow, as in the example below, where a question is ended with a period instead of a question mark. Usually the message is appropriate, as in the second exchange.

HOW MANY SHIPS APPROACH EACH PORT WHICH IS THE DESTINATION
>OF AT LEAST TWO SHIPS?
NOT IMPLEMENTED YET. PLEASE BE PATIENT.

DOES THE MAXIMUM CRUISING RANGE OF AIRCRAFT CARRIERS
>EXCEED THEIR NORMAL CRUISING RANGE?
NOT IMPLEMENTED YET. PLEASE BE PATIENT.

f. The Message NEGATIVE ARGUMENTS FOR SQRT

This message is clear enough. It is typical of diagnostic messages of a technical nature.

WHAT IS THE SQUARE ROOT OF -5?
NEGATIVE ARGUMENT FOR SQRT.

g. Messages Pertaining to Adding of Data and Definitions

The chapter on modifying (page 81) and the section on verbs (page 53) should be referred to in conjunction with these messages.

If one attempts to add an item of data that is already in the data base, this is signaled as in the messages below.

CAPT R. SPRUANCE IS COMMANDER OF THE KITTYHAWK.
DATA WAS ALREADY THERE.

CAPT 'R.' SPRUANCE:=NAME
'NEW WORD HAS ALREADY BEEN INTRODUCED.'

The following protocol illustrates messages that are generated in connection with definitions and introduction of verbs.

```
>DEF:LONGEST SHIP:"SHIP" WHOSE LENGTH IS THE MAX LENGTH OF "SHIP"
  REJECTED. VARIABLES MUST MATCH.
>DEF:LONGEST "SHIP": "SHIP" WHOSE LENGTH IS THE MAX
  LENGTH OF "SHIP"
5  DEFINED.
```

```
VERB:SHIPS "BELONG TO" NORWAY: NORWAY::
  INCORRECT FORMAT, REJECTED.
```

```
>WHAT IS THE DEFINITION OF DOWN?
  NO DEFINITIONS FOUND.
10 >VERB:NORWY "DOWN" IS THE TARU: NORWAY IS THE FLAG OF THE TARU
  ONE SIDE DID NOT PARSE, REJECTED.
  >VERB:NORWY????
  INCORRECT FORMAT, REJECTED.
```

```
WHAT IS THE DEFINITION OF DOWN?
15 NORWAY "DOWN" IS TARU: NORWAY IS THE FLAG OF TARU
  WHO OWNS THE TARU?
  INAPPROPRIATE USE OF VERB.
  WHAT COUNTRY OWNS THE TARU?
  NORWAY
```

The message in line 2 refers to the fact that no quotation marks appear around the word SHIP on the left-hand side.

In the case of verbs, a message such as in lines 7 and 13 appears if the user aborts the definition by typing in nonsense or in other ways disobeys the format.

A message such as line 11 refers to the fact that the word NORWY on the left-hand side is not known to the system.

The message in line 17, INAPPROPRIATE USE OF VERB, results from the way the verb was defined (for discussion on how verbs are defined see page 53). NORWAY is an inanimate noun (only persons are animate in this data base), therefore WHO in the question cannot refer to NORWAY. WHAT COUNTRY (or WHAT alone) gets the correct answer.

h. Messages Signaling Lack of Adequate Work Space

Sentences which require a great deal of processing may run into the problem of lack of processing space. The message in the example below alerts the user. The solution is to break up the sentence into simpler ones.

```
LIST THE CARGO, QUANTITY OF CARGO AND CALL SIGN
OF SHIPS WHICH DEPARTED NEW YORK AND WHICH NETHERLANDS,
WEST GERMANY OR NORWAY OWNS.
SYSTEM ERROR AT (PARSER '+4EC')
NO AVAILABLE LIST SPACE.
SENTENCE ABNORMALLY TERMINATED. VERSION MAY
HAVE BEEN ERRONEOUSLY MODIFIED. PROCEED.
```

When a good deal of work is done with a particular version, especially involving adding of data and definitions, available storage space may be used up. This is signaled by the message in the example below.

```
LIST THE DESTINATION AND EMPLOYMENT OF EACH SHIP WHOSE
DEPARTURE POINT WAS SOME EUROPEAN PORT.
SYSTEM ERROR AT (UTYB6 +07A)
UNABLE TO ALLOCATE ADDITIONAL EXTENTS.
SENTENCE ABNORMALLY TERMINATED. VERSION MAY
HAVE BEEN ERRONEOUSLY MODIFIED. PROCEED.
```

It is still possible to continue working with one's version if one uses simple sentences and does not add any new data or definitions. Otherwise one would have to free some space; see Chapter IV on versions.

i. Messages Signaling Bugs

It is doubtful if it is possible to produce a system of this degree of complexity that would be entirely free of bugs. When a bug is encountered, the system sends some message, of which the one below is a typical illustration.

```
LIST THE FLAG, CARGO TYPE AND QUANTITY OF\  
>CARGO OF SHIPS WHOSE DESTINATION IS\  
>ALEXANDRIA.  
ABNORMAL INTERRUPTION AT (EXPAND +06E).  
SENTENCE ABNORMALLY TERMINATED. VERSION MAY  
HAVE BEEN ERRONEOUSLY MODIFIED. PROCEED.
```

Despite the warning that the version may have been erroneously modified, in most cases the system recovers graciously without damage to the version, so that one can indeed proceed safely. Clearly, the sentence which hit the bug should be rephrased.

But to make certain that the version had not been modified, it may be good practice to repeat a couple of previous requests to check for the sameness of answers. In case a version does get modified, the only safe thing to do is to delete it and make a fresh copy of one's permanent version. This, unfortunately, means loss of new data and definitions if such had been added to the current version.

A-3. CONTINUATION OF AN INPUT LINE

Continuation beyond the admissible line length results in a double EH? answer. This can be avoided by using the conventions for line continuation. There are two possibilities: ending a given line on a completed word, and ending the line in the middle of a word. In the first case, only the line continuation character needs to be employed; in the second, the hyphenation character is also necessary. In the first case, the continuation character "\" should be placed after the last word; in the second case, the hyphen should be placed where the word is to be hyphenated, followed by the continuation character. The continuation character "\" by itself acts like a blank, and it is therefore not necessary to insert a blank after the last word in a line to be continued. Preceded by a hyphen, the "\" does not act like a blank and the word is simply continued. How this works can be illustrated as follows:

. . . DESTINATION\
OF SHIPS

is equivalent to: . . . DESTINATION OF SHIPS.

. . . DESTINAT-\
ION OF SHIPS

is equivalent to: . . . DESTINATION OF SHIPS.

The examples below show these points in actual use.

WHAT IS THE FLAG AND CARGO OF EACH MERCHANT
VESSEL WHOSE DESTINATION IS ALEXANDRIA AND
WHOSE DEPARTURE POINT IS SEVASTOPOL?
TASCO NORWAY AIRCRAFT
TAURUS NORWAY TANKS
TERNA NORWAY AIRCRAFT

WHAT IS THE FLAG, CARGO AND CALL SIGN OF MERC-
HANT VESSELS WHOSE DESTINATION IS ALEXANDRIA
AND WHOSE DEPARTURE POINT IS SEVASTOPOL?
NORWAY AIRCRAFT K404
K406
TANKS K405

B. SOME SIMPLE QUERIES

B-1. SIMPLE ENGLISH QUESTIONS ABOUT INDIVIDUALS

A query of the type WHAT IS THE FLAG OF THE CALIFORNIA STAR? and similar simple questions reflect well the data base and its organization. The basic types of REL English structure are individuals, classes, relations, and number relations. Examples of these follow.

A distinction, grammatically important, pertains to these categories, and that is of the feature of animate vs inanimate. Individuals, classes, and relations can be either animate or inanimate. Number relations, clearly, do not have this distinction. The significance of the distinction of the animate feature is with respect to the use of such words as WHO or HIS. The distinction of the animate vs inanimate should be observed when putting in new vocabulary items. This is discussed in the appropriate section (page 87).

```

WHAT IS THE FLAG OF THE CALIFORNIA STAR?
UNITED KINGDOM
>WHAT IS THE DESTINATION OF THE ROBISON?
LIVERPOOL
5 >WHAT IS THE CALL SIGN OF THE RATHBURNE?
NADB
>WHO IS THE COMMANDER OF THE LOS ANGELES?
CDR D. JONES
>WHO IS THE COMMANDING OFFICER OF THE KITTYHAWK?
10 CAPT R. SPRUANCE
>WHAT IS THE HULL NUMBER OF THE KITTYHAWK?
63
>WHAT IS THE MAXIMUM CRUISING SPEED OF THE KNOX?
27
15 >WHAT IS STERETT'S HOME PORT?
CHARLESTON
>WHAT IS ROARK'S ENDURANCE?
35
>WHAT IS THE NAME OF THE KITTYHAWK'S COMMANDING OFFICER?
20 CAPT R. SPRUANCE
>WHAT IS THE CONSTELLATION'S COMMANDER'S NAME?
CAPT J. ELLISON
>WHAT ARE THE LENGTH AND BEAM OF THE ROARK?
438 47
25 >WHAT ARE THE LENGTH, BEAM AND DRAFT OF THE CONSTELLATION?
1072 130 36
>IS NAPLES THE DESTINATION OF THE KITTYHAWK?
YES

```


>IS THE SARATOGA A NAVAL VESSEL?
 30 YES
 >IS THE HOME PORT OF THE KITTYHAWK CHARLESTON?
 NO
 >IS MAYPORT SARATOGA'S HOME PORT?
 NO
 35 >WHAT SHIP HAS HULL NUMBER 63?
 KITTYHAWK
 >DOES CAPT A. BROWN HAVE A SHIP?
 YES
 >DOES THE KITTYHAWK HAVE HULL NUMBER 63?
 40 YES
 >DOES THE LOS ANGELES HAVE A DOCTOR?
 NO
 >DOES THE AMERICA HAVE REPLENISHMENT AS EMPLOYMENT?
 NO
 45 >WHAT EMPLOYMENT DOES THE AMERICA HAVE?
 OVERHAUL
 >WHAT EMPLOYMENT DOES THE KNOX HAVE?
 UNKNOWN
 >WHAT IS AMERICA'S EMPLOYMENT?
 50 OVERHAUL
 >IS THERE A HULL NUMBER 855?
 YES
 >IS THERE A COMMANDER OF THE KNOX?
 YES
 55 >DOES CAPT R. SPRUANCE COMMAND THE KITTYHAWK?
 YES
 >WHO COMMANDS THE RATHBURNE?
 CDR W. MORAN
 >DOES THE TARIFA CARRY AIRCRAFT?
 60 YES
 >HAS THE TARU DEPARTED RIGA?
 YES
 >HAS NORFOLK BEEN DEPARTED BY TAER***ERNA?
 NO

An individual is exemplified in line 1: CALIFORNIA STAR, which is the name of a ship in this data base. A relation is exemplified in the same line by FLAG. Another individual is in line 2: UNITED KINGDOM.

Examples of Individuals

CALIFORNIA STAR, UNITED KINGDOM, ROBISON, KITTYHAWK, TARU, NORFOLK,
RIGA, NAPLES, REPLENISHMENT, UNKNOWN

Examples of Individuals (animate)

CDR D. JONES, CAPT R. SPRUANCE, CAPT A. BROWN

Examples of Classes

SHIP, NAVAL VESSEL, AIRCRAFT

Examples of Classes (animate)

[Not in this protocol; see page 90.]

Examples of Relations

FLAG, DESTINATION, CALL SIGN, HOME PORT, EMPLOYMENT

Examples of Relations (animate)

COMMANDER, COMMANDING OFFICER

Examples of Number Relations

HULL NUMBER, ENDURANCE, LENGTH

Examples of Numbers

63, 855

The possessive construction with 's (' for plural, e.g. SHIPS' COMMANDERS) is exemplified in lines 15, 17, 19, 21, 49.

Use of conjunctions is shown in lines 23 and 25.

The next few lines after 25 are yes/no type questions.

The verb HAVE appears in lines 35, 37 (in a question with DO), 39, 41, 43, 45, 47.

Lines 51 and 53 show the use of THERE.

Verbs other than IS and HAVE are illustrated in lines 55, 57, 61, and 63 (in passive form). For the discussion of verbs and how they can be introduced see page 53.

B-2. SIMPLE ENGLISH QUESTIONS ABOUT INDIVIDUALS

A variety of examples illustrate some structural types of questions that can be asked about classes such as LOS ANGELES CLASS SHIPS, TANKERS, TASK GROUPS, PORTS, EUROPEAN COUNTRY. English quantifiers such as EACH, WHAT, WHICH, HOW MANY, AT LEAST TWO provide good means of grouping data and obtaining listing of information about the members of a group. The questions below employ a number of quantifiers, but not all that can be used. The ones found in the examples are: WHAT, EACH, WHICH, ANY, SOME, HOW MANY, AT LEAST . . . , WHICH OF, HOW MANY OF, EACH OF, SOME OF, ANY OF, AT LEAST . . . OF. Not exemplified here are ALL, ALL OF, ALL BUT, EVERY, EACH OF, AT MOST, EXACTLY which, however, are found in examples in later sections. At present, ALL still runs into some difficulties, and there are no examples of ALL OF and ALL BUT. EVERY is exemplified in the section on relative clauses in line 99, and ALL in lines 106 and 109. AT MOST and EXACTLY are found in the section on comparisons. Numerous examples of quantifiers are in the section on formatting of output.

```

>WHAT ARE LOS ANGELES CLASS SHIPS?
  PHILADELPHIA
  BATON ROUGE
  LOS ANGELES
5 >WHAT ARE TANKERS?
  THERE ARE 40 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
  RESPOND WITH "ALL", "NONE", OR A NUMBER.
  >7
  ATLANTIC
10 PACIFIC
  ARABIAN SEA
  GUAMICO
  ANTARCTIC
  ARCTIC
15 INDIAN OCEAN
  >WHAT ARE TASK GROUPS?
  TG67.2
  TG27.7
  TG67.1
20 TG67.3
  TG24.2
  >WHAT IS THE ENDURANCE OF KITTYHAWK CLASS SHIPS?
  45
  45
25 45
  45
  >WHAT IS THE STATE OF READINESS OF TG67.1?
  C3
  C2
30 C1

```

>WHAT IS THE NUMBER OF HASSAYAMPA CLASS SHIPS?
 3
 >WHAT IS THE NUMBER OF FRIGATES?
 9
 35 >WHO ARE THE COMMANDERS OF CHARLES F. ADAMS CLASS SHIPS?
 CDR J. FOXX
 CDR F. HOLLISTER
 CDR R. BRANDENBURG
 CDR J. P. JONES
 40 CDR W. BURNS
 CDR W. T. DOOR
 CDR A. BURKE
 CDR C. PRESGROVE
 CDR P. OSGOOD
 45 CDR W. T. HATCH
 CDR W. HUNT
 >WHO IS THE COMMANDER OF EACH LOS ANGELES CLASS SHIP?
 PHILADELPHIA CDR L. SNEAK
 BATON ROUGE CDR V. QUIET
 50 LOS ANGELES CDR D. JONES
 >WHAT IS THE LINEAL OF THE COMMANDER OF EACH LOS ANGELES
 >CLASS SHIP?
 PHILADELPHIA 4840
 BATON ROUGE 4839
 55 LOS ANGELES 4838
 >WHAT IS THE EMPLOYMENT OF EACH HASSAYAMPA CLASS SHIP?
 KAWISHIWI REPLENISHMENT
 HASSAYAMPA REPLENISHMENT
 ASHTABULA REPLENISHMENT
 60 >WHAT IS THE PERCENT FUEL OF EACH TU24.2.2?
 HOEL 79
 ROBISON 89
 SELLERS 90
 TOWERS 90
 65 LYNDE B. MCCORMICK 95
 KNOX 90
 >WHAT ARE THE PORTS OF EACH EUROPEAN COUNTRY?
 FRANCE LEHAYRE
 ITALY NAPLES
 70 NORWAY OSLO
 NETHERLANDS ROTTERDAM
 UNITED KINGDOM LONDON
 LIVERPOOL
 GIBRALTAR
 75 PORTUGAL LISBON

THE CARGO OF WHAT SHIPS IS OIL?
THERE ARE 40 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
RESPOND WITH "ALL", "NONE", OR A NUMBER.

>5

80 ATLANTIC
PACIFIC
ARABIAN SEA
SUAHICO
ANTARCTIC

85 >THE HOME PORT OF WHICH SHIPS IS MAYPORT?
CONSTELLATION
KITTYHAWK
JOHN F. KENNEDY
INDEPENDENCE

90 >EACH EUROPEAN PORT IS THE DESTINATION OF WHAT SHIPS?
THERE ARE 69 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
RESPOND WITH "ALL", "NONE", OR A NUMBER.

>10

LEHAVRE TAMESIS
95 NAPLES CONSTELLATION
KITTYHAWK
HASSAYAMPA
ASHTABULA
TANCRED
100 OSLO TAIPING
TAGRIS
TAGAYTRAY
TABOR

>ARE ANY SHIPS IN TU24.2.2 AIRCRAFT CARRIERS?

105 NO

>IS OSLO THE DESTINATION OF SOME LIBERIAN SHIP?

NO

>IS THE HULL NUMBER OF SOME SOVIET SHIP GREATER THAN 1000?

NO

110 >HOW MANY SHIPS ARE IN T624.2?

20

>HOW MANY KNOX CLASS SHIPS ARE THERE?

9

>HOW MANY COMMANDERS OF KNOX CLASS SHIPS ARE THERE?

115 9

>WHAT TASK GROUPS ARE THERE?

T667.2

T627.7

T667.1

120 T667.3

T624.2

>ARE THERE AT LEAST 5 FRIGATES?
 YES
 >WHAT SHIP HAS HULL NUMBER 855?
 125 ADMIRAL GOLOVKO
 >WHAT AIRCRAFT CARRIERS HAVE DOCTORS?
 CONSTELLATION
 SARATOGA
 AMERICA
 130 KITTYHAWK
 JOHN F. KENNEDY
 INDEPENDENCE
 >WHAT SHIP DOES CDR C. JACKSON HAVE?
 KNOX
 135 >WHAT SHIPS HAVE NAPLES AS DESTINATION?
 CONSTELLATION
 KITTYHAWK
 MASSACHUSETTS
 ASHTABULA
 140 TANCRED
 >DO ANY SOVIET SHIPS HAVE PERCENT FUEL LESS THAN 30?
 NO
 >HOW MANY SOVIET SHIPS HAVE SPEED GREATER THAN 15?
 3
 145 >WHAT COUNTRIES HAVE PORTS?
 UNITED STATES
 SOVIET UNION
 EGYPT
 FRANCE
 150 ITALY
 VENEZUELA
 SAUDI ARABIA
 ANGOLA
 LIBERIA
 155 NORWAY
 SOUTH AFRICA
 NETHERLANDS
 UNITED KINGDOM
 PORTUGAL
 160 ARGENTINA
 >WHAT COUNTRY HAS EACH PORT?
 UNITED STATES MAYPORT
 NORFOLK
 BALTIMORE
 165 NEW YORK
 WASHINGTON
 WILMINGTON
 SOVIET UNION SEVASTOPOL
 RIGA

170 EGYPT ALEXANDRIA
 FRANCE LEHAVRE
 ITALY NAPLES
 VENEZUELA CARACAS
 SAUDI ARABIA ALMANAMAH
 175 ANGOLA MOCAMEDES
 LUANDA
 LIBERIA MONROVIA
 NORWAY OSLO
 SOUTH AFRICA CAPE TOWN
 180 NETHERLANDS ROTTERDAM
 UNITED KINGDOM LONDON
 LIVERPOOL
 GIBRALTAR
 PORTUGAL LISBON
 185 ARGENTINA BUENOS AIRES
 >WHICH OF THE AIRCRAFT CARRIERS HAVE NAPLES AS DESTINATION?
 CONSTELLATION
 KITTYHAWK
 >HOW MANY OF THE US SHIPS HAVE PERCENT FUEL GREATER THAN
 190 >90?
 20
 >DOES EACH OF THE AIRCRAFT CARRIERS HAVE A DOCTOR?
 CONSTELLATION YES
 SARATOGA YES
 195 AMERICA YES
 KITTYHAWK YES
 JOHN F. KENNEDY YES
 INDEPENDENCE YES
 >IS THE ENDURANCE OF SOME OF THE SUBMARINES LESS THAN 20?
 200 NO
 >DOES ANY OF THE COMMANDERS OF US SHIPS HAVE A LINEAL
 >HIGHER THAN 10000?
 YES
 >DO AT LEAST 18 OF THE MERCHANT VESSELS CARRY OIL?
 205 YES
 >COMBAT READINESS RATING OF WHAT SHIPS IS NOT C1?
 AMERICA
 KITTYHAWK
 STERETT
 210 CHARLES F. ADAMS
 HOEL
 CONNOLLY
 RATHBURN
 MEYERKORD
 215 >THE DESTINATION OF WHAT US SHIPS IS NOT NAPLES?
 THERE ARE 71 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
 RESPOND WITH "ALL", "NONE", OR A NUMBER.
 >5
 SARATOGA
 220 AMERICA
 JOHN F. KENNEDY
 INDEPENDENCE
 STURGEON

THE PERCENT FUEL OF WHAT US SHIPS IS NOT LESS THAN 80?
 225 THERE ARE 40 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
 RESPOND WITH "ALL", "NONE", OR A NUMBER.
 >5
 CONSTELLATION
 SARATOGA
 230 KITTYHAWK
 JOHN F. KENNEDY
 INDEPENDENCE
 >THE CARGO OF HOW MANY NORWEGIAN SHIPS IS NOT OIL?
 19
 235 THE DESTINATION OF WHAT US SHIPS IS UNKNOWN?
 AMERICA
 JOSEPHUS DANIELS
 SOUTH CAROLINA
 CALIFORNIA
 240 WAINWRIGHT
 FOX
 WILLIAM H. STANDLEY
 STERETT
 HORNE
 245 JOUETT
 BIDDLE
 KNOX

The questions in lines 1-27 result in a single list, those in lines 31 and 33 in a count. If an answer exceeds a certain length, 30 lines, the user is given the option of obtaining only part of the answer, as is shown in line 6. In lines 47-67 the questions result in a listing in two columns. Nonnumerical and numerical data may be mixed, as in line 60. In questions in lines 76-90, WHAT does not appear at the beginning of the question. Lines 104-108 are yes/no type questions. Lines 112-122 show the use of THERE. In lines 124-192 the verb HAVE is employed. Numerical comparisons are found in lines 108, 141, 143, 189, 199, 202, and 224. Comparisons are further discussed and further exemplified in on page 48 ff. The verb CARRY is used in line 204 in a yes/no question. Lines 206, 215, 224, and 233 contain the negative NOT. The use of UNKNOWN is shown in line 235.

A great many of the possible sentence types involving combinations of some of the structural elements introduced so far and later in this book cannot all be illustrated here. It is hoped, however, that from these examples a user may start having a feel for the variety of sentences that can be constructed.

C. TENSE AND TIME

REL English includes capabilities for handling tenses other than present, i.e. past and future, as well as explicit references to time of events, i.e. dates. The smallest unit of time in REL English is a day. The time span covered is from 1826 to 2000. NOW refers to the day the user signed on the terminal. These capabilities cannot, however, be illustrated on the Navy data base since it does not include time information. To include examples of how tense and time is handled, a small data base was constructed dealing with contracts which have various time intervals attached to them.

The protocol below illustrates the use of tenses and a variety of times. Comments and explanations follow the protocol.

```

LIST MICROPROCESSOR CONTRACTS.
NI-76-6   STARTING DECEMBER 1976 ENDING NOVEMBER 1978
NI-74-16  STARTING MARCH 15, 1974 ENDING MARCH 14, 1977
NI-74-12  STARTING APRIL 15, 1974 ENDING APRIL 14, 1976
5 NI-77-14 STARTING 1977 ENDING 1978
NI-76-17  STARTING JUNE 1976 ENDING MAY 1978
NI-76-24  STARTING MAY 1976 ENDING APRIL 1978
NI-76-31  STARTING OCTOBER 1976 ENDING SEPTEMBER 1978
NI-77-12  STARTING DECEMBER 15, 1977 ENDING DECEMBER 14, 1978
10 NI-77-3  STARTING OCTOBER 10, 1977 ENDING OCTOBER 09, 1978
>WHAT ARE THE CONTRACTORS AND AMOUNTS OF CURRENT\
>MICROPROCESSOR CONTRACTS?
GENERAL DATA CORP          84000
DENVER-GRAHM CORP          198000
15 A. JOHN CORP             58000
COMPUTER CONSULTANTS INTNL  18000
MIAMI STATE UNIVERSITY     96000
>WHO WAS THE PRINCIPAL INVESTIGATOR AND CONTRACTOR OF EACH\
>OCTOBER 1, 1977 MICROPROCESSOR CONTRACT?
20 NI-76-6   H. LANSDALE  GENERAL DATA CORP
NI-77-14    L. MC COY    DENVER-GRAHM CORP
NI-76-17    P. LOST      COLORADO INST OF TECH
NI-76-24    C. CHARLES   NATIONAL BUSINESS MACHINES
NI-76-31    H. CHANG     A. JOHN CORP

```

25> WHAT WAS THE CLASSIFICATION OF EACH CONTRACT IN OCTOBER 1977?

NI-73-28	INSTITUTIONAL	
NI-74-5	INSTITUTIONAL	
NI-75-4	NETWORKS AND COMMUNICATIONS	
NI-76-28	INSTITUTIONAL	
30 NI-76-10	NETWORKS AND COMMUNICATIONS	ENDING OCTOBER 19, 1977
NI-76-6	MICROPROCESSORS	
NI-77-14	MICROPROCESSORS	
NI-76-17	MICROPROCESSORS	
NI-76-24	MICROPROCESSORS	
35 NI-76-31	MICROPROCESSORS	STARTING OCTOBER 10, 1977
NI-77-3	MICROPROCESSORS	
NI-76-33	ARTIFICIAL INTELLIGENCE	
NI-76-13	ARTIFICIAL INTELLIGENCE	
NI-76-3	ARTIFICIAL INTELLIGENCE	ENDING OCTOBER 22, 1977
40 NI-76-30	ARTIFICIAL INTELLIGENCE	ENDING OCTOBER 13, 1977
NI-76-15	ARTIFICIAL INTELLIGENCE	
NI-76-7	SOFTWARE ENGINEERING	
NI-76-20	SOFTWARE ENGINEERING	
NI-76-12	SOFTWARE ENGINEERING	
45 NI-77-5	SOFTWARE ENGINEERING	
NI-77-15	THEORETICAL COMPUTER SCIENCE	
NI-76-34	THEORETICAL COMPUTER SCIENCE	
NI-76-25	THEORETICAL COMPUTER SCIENCE	
NI-77-8	THEORETICAL COMPUTER SCIENCE	

50> WHAT WAS THE AMOUNT OF THE JUNE 1975 CONTRACTS WITH EACH CLASSIFICATION?

ARTIFICIAL INTELLIGENCE	180000
SOFTWARE ENGINEERING	108000
55 INSTITUTIONAL	46000
	176000
	600000
	220000
THEORETICAL COMPUTER SCIENCE	28000
60 MICROPROCESSORS	18000
	40000
NETWORKS AND COMMUNICATIONS	32000
	66000

> WHAT WAS THE TOTAL AMOUNT OF JUNE 1975 CONTRACTS WITH EACH CLASSIFICATION?

65 ARTIFICIAL INTELLIGENCE	288000
SOFTWARE ENGINEERING	222000
INSTITUTIONAL	820000
THEORETICAL COMPUTER SCIENCE	28000
MICROPROCESSORS	58000
70 NETWORKS AND COMMUNICATIONS	98000

> HOW MANY AI CONTRACTS ARE THERE?

NONE.

> HOW MANY AI CONTRACTS WERE THERE IN LAST YEAR?

2	STARTING NOVEMBER 07, 1977
75 3	STARTING OCTOBER 23, 1977 ENDING NOVEMBER 06, 1977
4	STARTING OCTOBER 14, 1977 ENDING OCTOBER 22, 1977
5	STARTING SEPTEMBER 22, 1977 ENDING OCTOBER 13, 1977
6	STARTING AUGUST 17, 1977 ENDING SEPTEMBER 21, 1977
7	STARTING JULY 17, 1977 ENDING AUGUST 16, 1977
80 8	STARTING MAY 30, 1977 ENDING JULY 16, 1977
9	ENDING JANUARY 15, 1977
	STARTING MAY 02, 1977 ENDING MAY 20, 1977
10	STARTING JANUARY 16, 1977 ENDING MAY 01, 1977

> AND WAS THE PRINCIPAL INVESTIGATOR OF EACH STANDARD UNIVERSITY?

85> CONTRACT AFTER JUNE 1, 1977?

NI-76-28	H. CHAMBERS	STARTING NOVEMBER 1976
NI-76-33	H. CHAMBERS	ENDING MARCH 04, 1978
NI-76-7	V. MILLSAPS	ENDING FEBRUARY 1978
NI-77-19	H. CHAMBERS	STARTING 1977 ENDING JUNE 1977

90>WHAT WERE THE AMOUNTS AND CLASSIFICATIONS OF CONTRACTS WHOSE
 >PRINCIPAL INVESTIGATOR WAS H. CHAMBERS?

480000 INSTITUTIONAL

STARTING NOVEMBER 1976

60000 ARTIFICIAL INTELLIGENCE

95 STARTING MARCH 05, 1976 ENDING MARCH 04, 1978

14000 THEORETICAL COMPUTER SCIENCE

STARTING 1977 ENDING JUNE 1977

>LIST THE AMOUNTS AND PRINCIPAL INVESTIGATORS OF CURRENT

>CONTRACTS WHICH WERE CONTRACTS BEFORE JUNE 1977.

100 600000 T. BURDICK STARTING OCTOBER 1973

220000 D. ARCHER STARTING JUNE 1974

480000 H. CHAMBERS STARTING NOVEMBER 1976

84000 H. LANSDALE STARTING DECEMBER 1976

198000 L. MC COY STARTING 1977

105 58000 H. CHANG STARTING OCTOBER 1976

62000 A. COPPI STARTING NOVEMBER 21, 1976

40000 R. GASPAR STARTING AUGUST 15, 1976

>WHAT WAS THE SUM, MAX, MIN AND MEAN OF THE AMOUNTS OF JANUARY 1,

>1978 CONTRACTS WITH EACH CLASSIFICATION?

110	ARTIFICIAL INTELLIGENCE	108000	60000	48000	54000
	SOFTWARE ENGINEERING	196000	87000	47000	65333.3
	INSTITUTIONAL	1.3E+06	600000	220000	433333
	THEORETICAL COMPUTER SCIENCE	25000	40000	21000	31666.7
	MICROPROCESSORS	748000	198000	18000	106857
115	NETWORKS AND COMMUNICATIONS	66000	66000	66000	66000

>WHAT WAS THE TOTAL AMOUNT OF JANUARY 1, 1978 CONTRACTS

>OF EACH CONTRACTOR?

	COLORADO INST OF TECH	346000
	INFORMATION SCI CORP	634000
120	MELLON UNIVERSITY	66000
	STANDARD UNIVERSITY	627000
	GENERAL DATA CORP	84000
	DENVER-GRAHAM CORP	198000
	NATIONAL BUSINESS MACHINES	168000
125	A. JOHN CORP	58000
	COMPUTER CONSULTANTS INTNL	18000
	MIAMI STATE UNIVERSITY	96000
	MINNESOTA POLYTECHNIC INST	48000
	MULTIVAC CORP	109000
130	WYOMING STATE UNIVERSITY	40000
	AUTHUR J. BIGGER CORP	21000

Line 1 is a command that holds for all time, i.e. all microprocessor contracts are listed, with their times, both those that are currently continuing, as in line 2, and those that had already ended, as in line 3.

CURRENT contracts which are inquired about in line 11 are limited to those that are in existence at the particular time that the user is working. Thus, as can be seen from lines 13-17, there are 5 contracts in existence. These correspond to lines 2, 5, 8, 9, and 10 of the previous answer.

Time information can precede the noun which it modifies, as in lines 19, 50, 63.

The time information may consist of a specific day, as in line 19, or cover a longer interval, e.g. a month, as in line 25, or a year, as in line 73. If a period such as a month is used, as in line 25, contracts which were in existence throughout the period are listed (lines 28, 29), and also contracts which ended or started within the period, with the appropriate information (lines 30, 36).

In line 71 the present tense elicits the answer NONE. As can be seen from the lines that follow, a number of such contracts existed in the previous year. Line 82 means that there were 9 contracts also starting May 02, 1977 and ending May 29, 1977.

Prepositions such as IN (line 25), AFTER (line 85), BEFORE (line 99) can be used in their ordinary meanings.

If a question is in a given tense, e.g. in the past tense, as in lines 90-91, but there is no time expression to specify the time period, the tense of the verb determines the answer. In the case of the past, events that existed in the past and that either ended in the past or continue in the present moment are considered.

Various complex operations can be performed on data with attached times, such as total (sum), maximum, minimum, mean, as can be seen from lines 63, 108, 116.

Line 1 is a command that holds for all time, i.e. all microprocessor contracts are listed, with their times, both those that are currently continuing, as in line 2, and those that had already ended, as in line 3.

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In line 71 the present tense elicits the answer NONE. As can be seen from the lines that follow, a number of such contracts existed in the previous year. Line 82 means that there were 9 contracts also starting May 02, 1977 and ending May 29, 1977.

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If a question is in a given tense, e.g. in the past tense, as in lines 90-91, but there is no time expression to specify the time period, the tense of the verb determines the answer. In the case of the past, events that existed in the past and that either ended in the past or continue in the present moment are considered.

Various complex operations can be performed on data with attached times, such as total (sum), maximum, minimum, mean, as can be seen from lines 63, 108, 116.

D. MORE COMPLEX QUERIES

D-1. QUERIES WITH RELATIVE SUBORDINATE CLAUSES

Relative subordinate clauses supply some information about the noun to which they are attached, for instance, SHIPS THAT CARRY COAL. They function as a unit with the noun which they modify in the main sentence. They refer to the noun by means of relative pronouns WHO, WHICH, THAT, and WHOSE. Comments and explanations follow the protocol.

WHAT IS THE NAME OF THE OFFICER WHO COMMANDS THE BIDDLE?
CAPT J. TOWNES

>IS THE LINEAL OF THE OFFICER WHO COMMANDS THE KNOX
>GREATER THAN 5000?

5 YES

>WHAT ARE THE LINEALS OF OFFICERS WHO COMMAND EACH
>SHIP WHOSE HOME PORT IS CHARLESTON?

	JOSEPHUS DANIELS	4843
	SOUTH CAROLINA	4842
10	CALIFORNIA	4841
	FOX	4849
	WILLIAM H. STANDLEY	4848
	STERETT	4847
	HORNE	4846
15	JOQUETT	4845
	BIDDLE	4850
	KNOX	10012
	CONNOLLY	10016
	HEPBURN	10015
20	GRAY	10014
	ROARK	10013
	RATHBURNE	10017
	LANG	10020
	W. S. SIMS	10019
25	MEYERKORD	10018

HOW MANY SHIPS ARE THERE THAT HAVE A DOCTOR?

22

>HOW MANY SHIPS ARE THERE THAT HAVE NAPLES AS DESTINATION?

5

30 >WHAT SHIPS THAT HAVE NAPLES AS DESTINATION ARE THERE?

CONSTELLATION

KITTYHAWK

HASSAYAMPA

ASHTABULA

35 TANCRED

>HOW MANY SHIPS ARE THERE THAT HAVE MAXIMUM CRUISING

>SPEEDS NOT LESS THAN 35?

13

>WHAT ARE THE FLAGS OF SHIPS THAT CARRY TANKS?

40 NORWAY

WEST GERMANY

NETHERLANDS

UNITED KINGDOM

>WHAT DO SHIPS THAT DEPARTED LONDON CARRY?

45 GENERAL MERCHANDISE

>WHAT DOES EACH SHIP THAT DEPARTED RIGA CARRY?

TARU AIRCRAFT

TARANTEO TANKS

>DOES EACH SHIP THAT DEPARTED RIGA CARRY AIRCRAFT?

50 TARU YES

TARANTEO NO

>WHAT IS THE DESTINATION OF SHIP THAT HAVE DEPARTED

>LONDON?

ROTTERDAM

55 LEHAVRE

>DO SHIPS THAT DEPARTED LONDON HAVE ROTTERDAM AS DES-

>TINATION?

YES

>DO SOME SHIPS THAT DEPARTED OSLO CARRY OIL?

60 YES

>DOES THE SHIP WHICH CAPT R. SPRUANCE COMMANDS HAVE

>MAYPORT AS HOME PORT?

YES

>DO SOME SHIPS WHICH CARRY COAL HAVE BALTIMORE AS

65 >DEPARTURE POINT?

NO

>WHAT DO SHIPS WHOSE DEPARTURE POINT IS BALTIMORE CARRY?

GENERAL FOODS

CONSTRUCTION MATERIALS

70 >DOES THE SHIP WHICH CDR C. JACKSON COMMANDS HAVE

>ENDURANCE GREATER THAN 70?

NO

WHAT IS THE ENDURANCE OF THE SHIP WHICH CDR C. JACKSON
 COMMANDS?
 75 35
 DOES THE SHIP WHICH CAPT R. SPRUANCE COMMANDS
 APPROACH NAPLES?
 YES
 DOES ANY SHIP WHOSE DEPARTURE POINT IS SOME US PORT
 80 CARRY AIRCRAFT?
 YES
 DO SHIPS WHOSE NORMAL CRUISING SPEEDS EXCEED 15 HAVEN
 PERCENT FUEL GREATER THAN 70?
 YES
 85 THE PERCENT FUEL OF WHAT SHIPS WHOSE NORMAL CRUISING
 SPEEDS EXCEED 15 IS GREATER THAN 70?
 THERE ARE 46 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
 RESPOND WITH "ALL", "NONE", OR A NUMBER.
 9
 90 CONSTELLATION
 SARATOGA
 KITTYHAWK
 JOHN F. KENNEDY
 INDEPENDENCE
 95 JOSEPHUS DANIELS
 WAINWRIGHT
 FOX
 WILLIAM H. STANDLEY
 DOES EVERY AIRCRAFT CARRIER WHICH HAS A DOCTOR SAIL FOR
 100 SOME EUROPEAN PORT?
 NO
 IS ANY SUBMARINE WHOSE SPEED IS GREATER THAN OR EQUAL TO
 10 OWNED BY USSR OR US?
 UNITED STATES NO
 105 SOVIET UNION YES
 ARE ALL AIRCRAFT CARRIERS WHOSE DESTINATION IS NAPLES
 OWNED BY US?
 YES
 DO ALL MERCHANT VESSELS WHICH CARRY OIL OR AMMUNITION
 110 BELONG TO US?
 AMMUNITION NO
 OIL NO

In the protocol WHO is found in lines 1, 3, 6; WHICH is in lines 61, 64, 70, 73, 76, 99, and 109; WHOSE is in lines 7, 67, 79, 82, 85, 102, and 106. The rest of the sentences contain THAT. The verbs BE and HAVE occur in these relative clauses, but regular verbs such as DEPART predominate.

Relative clauses are either attached at the end or possible end of the main sentence as in line 1, . . . OFFICER WHO COMMANDS THE BIDDLE?, or embedded within the sentence as in line 3, . . . OFFICER WHO COMMANDS THE KNOX GREATER. . . . The two types of constructions are indicated with the lines where they occur.

Lines 6 and 7 contain two relative clauses, each of which could end the sentence, i.e. be final. The presence of EACH results in the listing.

Line 30 has an embedded clause also with the THERE construction.

Line 37 has a final clause that contains a comparative.

In line 39 the clause is final and contains a regular verb.

Line 44 contains a clause with a regular verb embedded in the main sentence with a regular verb.

Line 46 is similar to line 44 but contains EACH.

Line 49 is a yes/no question with EACH and an embedded clause.

Line 56 is similar to line 49 but is without EACH.

Line 59 is similar to line 49, but contains SOME.

Line 61 has an embedded clause with a subject that is different from the noun which the clause modifies.

Line 64 has an embedded clause.

Line 67 contains an embedded clause with the pronoun WHOSE. In such clauses the subject is different from the noun which the clause modifies.

In line 70 the embedded clause has a different subject and the main sentence contains a comparison.

Line 73 has a final relative clause with a different subject.

Line 76 contains an embedded clause with a different subject.

In line 79 the embedded relative clause has the pronoun WHOSE and the quantifier SOME.

Line 82 has an embedded clause with WHOSE and a comparison,

and the main sentence also has a comparison.

In line 85 almost all the words are the same as in line 82 but due to a different grammatical structure different results are obtained. The relative clause contains WHOSE and is embedded.

Line 99 contains an embedded relative clause with WHICH. There are two quantifiers -- EVERY and SOME. The verb SAIL FOR is shown in the section on verbs.

In line 102 the relative clause starts with WHOSE, is embedded, and contains a comparison. The ANY quantifier is present. The passive verb IS . . . OWNED is treated in the section on verbs. The conjunction OR is discussed in the section on conjunctions.

Line 106 is somewhat similar to the above, but contains the quantifier ALL.

In line 109 the relative clause is also embedded but it starts with WHICH. The verb BELONG TO is shown in the section on verbs.

A special case of sentences with relative clauses are elliptical sentences which on the surface do not contain a relative clause. Examples are found in the protocol below.

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WHAT ARE AIRCRAFT CARRIERS WITH EACH MISSION?
SURVEILLANCE OPERATIONS      CONSTELLATION
" " " " " " " " " " " " " " KITTYHAWK
" " " " " " " " " " " " " " JOHN F. KENNEDY
5 TENDER RESTRICTED AVAILABILITY SARATOGA
" " " " " " " " " " " " " " INDEPENDENCE
OVERHAUL " " " " " " " " " " AMERICA
> HOW MANY AIRCRAFT CARRIERS WITH EACH FLAG ARE THERE?
UNITED STATES 6
10 SOVIET UNION 4
> ARE THERE MORE THAN TWO SUBMARINES WITH EACH EMPLOYMENT?
ROUTINE MAINTENANCE YES
SURVEILLANCE OPERATIONS NO
ANTI-SHIPING OPERATIONS NO
15 ANTI-SUBMARINE OPERATIONS YES
> HOW MANY AIRCRAFT CARRIERS WITH EACH MISSION HAVE A DOCTOR?
SURVEILLANCE OPERATIONS " " 3
TENDER RESTRICTED AVAILABILITY 2
OVERHAUL " " " " " " 1
20 HOW MANY SUBMARINES WITH HOME PORTS ARE THERE?
10
> WHAT SUBMARINES WITH SPEEDS GREATER THAN 5 ARE THERE?
ASPRO
SONFISH
25 USSR 17

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Such sentences contain elliptical, or truncated, relative clauses where the relative pronoun and the verb, usually HAVE, have been substituted by WITH. Thus, HOW MANY AIRCRAFT CARRIERS WITH EACH MISSION HAVE A DOCTOR? is equivalent to HOW MANY AIRCRAFT CARRIERS WHICH HAVE EACH MISSION HAVE A DOCTOR? The elliptical construction results in a shorter and smoother sentence.

Just as in the case of relative clauses, the WITH constructions can be sentence final or embedded. In lines 1 and 11 they are final, and in lines 8, 16, 20, 22 they are embedded.

D-2. CONJUNCTIONS

Noun phrases (including single nouns) can be conjoined with other noun phrases; verb phrases (including single verbs) with other verb phrases; and relative clauses with relative clauses. The conjunction words are AND and OR. The protocol below illustrates some of the possibilities of using conjunctions. Comments and explanations follow the protocol.

WHAT ARE THE DESTINATIONS OF KITTYHAWK AND LOS ANGELES?
 KITTYHAWK NAPLES
 LOS ANGELES NORFOLK
 >WHAT ARE THE DESTINATIONS OF THE LOS ANGELES AND
 5 >KITTYHAWK CLASS SHIPS?
 CONSTELLATION NAPLES
 AMERICA UNKNOWN
 KITTYHAWK NAPLES
 JOHN F. KENNEDY NORFOLK
 10 >LOS ANGELES NORFOLK
 >DOES ANY SHIP CARRY TANKS AND AIRCRAFT?
 AIRCRAFT YES
 TANKS YES
 >WHAT SHIPS CARRY TANKS AND COAL?
 15 >TANKS CANADIAN STAR
 AMSTELHOF
 TRANSAMERICA
 POSEIDON
 TARANTE
 20 >COAL ENGLISH STAR
 EMPIRE STAR
 DUNEDIN STAR
 AMSTELDIEP
 25 >HOW MANY SHIPS CARRY TANKS AND AIRCRAFT?
 AIRCRAFT 9
 TANKS 6
 >HOW MANY SHIPS ARE THERE WHICH CARRY AIRCRAFT, TANKS
 >OR TRUCKS?
 30 >AIRCRAFT 9
 TANKS 6
 TRUCKS 2
 >WHAT IS THE HULL NUMBER AND HOME PORT OF EACH AIRCRAFT
 >CARRIER?
 35 >CONSTELLATION 64 MAYPORT
 SARATOGA 60 NORFOLK
 AMERICA 66 NORFOLK
 KITTYHAWK 63 MAYPORT
 JOHN F. KENNEDY 67 MAYPORT
 40 >INDEPENDENCE 62 MAYPORT

>WHAT IS THE DESTINATION, PERCENT FUEL AND ENDURANCE
>OF EACH SHIP WHOSE HOME PORT IS NORFOLK?

	SARATOGA	6000N X 3000W	100	45
	AMERICA	UNKNOWN	0	45
45	STURGEON	0N X 4500E	100	96
	PHILADELPHIA	NORFOLK	100	130
	BATON ROUGE	NORFOLK	100	130
	LOS ANGELES	NORFOLK	100	130
	POGY	NORFOLK	100	96
50	GRAYLING	3500N X 1000E	100	96
	TAUTOG	3700S X 2000E	100	96
	WHALE	1500S X 1300E	100	96
	ASPRO	NORFOLK	100	96
	SUNFISH	NORFOLK	100	96
55	CHARLES F. ADAMS	NEW YORK	80	40
	HENRY B. WILSON	NEW YORK	90	40
	BARNEY	NEW YORK	95	40
	CLAUDE V. RICKETTS	NEW YORK	88	40
	LAWRENCE	NEW YORK	86	40
60	JOHN KING	NEW YORK	80	40
	HOEL	LIVERPOOL	79	40
	ROBISON	LIVERPOOL	89	40

>WHAT IS THE READINESS, CALL SIGN, MAXIMUM CRUISING
>SPEED AND ENDURANCE OF EACH SHIP WHICH HAS NAPLES AS

65 >DESTINATION?

	CONSTELLATION	C1	NABC	35	45
	KITTYHAWK	C2	NABE	35	45
	HASSAYAMPA	C1	NADF	25	60
	ASHTABULA	C1	NADH	25	60

70 >WHAT SHIPS HAVE OSLO OR LISBON AS DESTINATION?

	OSLO	TAIPING
		TAGRIS
		TAGAYTRAY
		TABOR

75	LISBON	TENNESSEE
		TENERIFFA
		TENNERAIRE

>WHAT ARE DESTINATIONS AND EMPLOYMENTS OF SHIPS THAT
>DEPARTED MAYPORT OR NORFOLK?

80	MAYPORT	6000N X 3000W	TENDER RESTRICTED AVAILABILITY
		3700N X 1700E	TENDER RESTRICTED AVAILABILITY
	NORFOLK	UNKNOWN	OVERHAUL
		0N X 4500E	ROUTINE MAINTENANCE
		3500N X 1000E	ROUTINE MAINTENANCE
85		3700S X 2000E	ROUTINE MAINTENANCE
		1500S X 1300E	ROUTINE MAINTENANCE

WHAT IS THE CALL SIGN, DESTINATION AND EMPLOYMENT OF EACH
 SHIP THAT DEPARTED MAYPORT OR NORFOLK?
 MAYPORT SARATOGA NABG 6000N X 3000W
 90 TENDER RESTRICTED AVAILABILITY
 INDEPENDENCE NABH 3700N X 1700E
 TENDER RESTRICTED AVAILABILITY
 NORFOLK AMERICA NABF UNKNOWN
 OVERHAUL
 95 STURGEON NABL 10N X 4500E
 ROUTINE MAINTENANCE
 GRAYLING NABO 3500N X 1000E
 ROUTINE MAINTENANCE
 TAUTOG NABN 3700S X 2000E
 100 ROUTINE MAINTENANCE
 WHALE NABM 1500S X 1300E
 ROUTINE MAINTENANCE
 WHAT ARE THE DESTINATIONS OF THE SHIPS WHICH CARRY TANKS
 AND WHICH DEPARTED RIGA?
 105 LUANDA
 WHAT ARE SHIPS WHOSE MAXIMUM CRUISING RANGE IS EQUAL
 TO 4000 AND WHICH HAVE PERCENT FUEL GREATER THAN 90?
 CONSTELLATION
 SARATOGA
 110 INDEPENDENCE
 IS THERE A SHIP WHOSE DESTINATION IS OSLO AND THAT HAS
 BUENOS AIRES AS DEPARTURE POINT?
 YES
 WHAT IS THE CARGO TYPE OF SHIPS WHICH DEPARTED RIGA?
 115 AND WHOSE DESTINATION IS LUANDA?
 AIRCRAFT
 TANKS
 ARE THERE SHIPS THAT DEPARTED MAYPORT AND WHICH HAVEN
 PERCENT FUEL NOT LESS THAN 100?
 120 YES
 WHAT IS THE EMPLOYMENT, HULL NUMBER AND CALL SIGN OF
 SHIPS WHICH ARE IN T667.3 AND WHICH DEPARTED MAYPORT?
 TENDER RESTRICTED AVAILABILITY 60 NABG
 62 NABH
 125 ARE THERE SHIPS IN T667.1 WHOSE READINESS IS C1 AND
 WHICH HAVE A DOCTOR?
 YES
 WHO IS THE COMMANDER OF EACH SHIP IN T667.1 WHOSE PERCENT
 FUEL IS NOT LESS THAN 50 AND WHICH HAS A DOCTOR?
 130 KITTYHAWK CAPT R. SPRUANCE
 WAINWRIGHT CAPT D. EVANS
 WILLIAM H. STANDLEY CAPT C. MICHAELS
 STERETT CAPT W. HOHMANN
 HORNE CAPT J. BRANIN
 135 JOUETT CAPT T. FRENZINGER
 IS NORFOLK THE HOME PORT OF EACH SHIP IN T667.3 WHOSE
 READINESS IS C1 AND WHICH DEPARTED MAYPORT?
 SARATOGA YES
 INDEPENDENCE NO

140 >WHAT PORTS DOES TARU APPROACH OR DEPART?
 LUANDA
 RIGA
 >WHAT SHIPS APPROACH OR DEPART NORFOLK OR MAYPORT?
 MAYPORT SARATOGA
 145 INDEPENDENCE
 NORFOLK AMERICA
 JOHN F. KENNEDY
 STURGEON
 PHILADELPHIA
 150 BATON ROUGE
 LOS ANGELES
 POGY
 GRAYLING
 TAUTOG
 155 WHALE
 ASPRO
 SUNFISH
 KAWISHIWI
 WHAT SHIPS SAIL TO LISBON AND CARRY CONSTRUCTION
 160 MATERIALS?
 TENERIFFA
 >WHAT SHIPS SAIL TO LISBON OR CARRY CONSTRUCTION MATERIALS?
 TALISMAN
 TANA
 165 TALLEYRAND
 TENNESSEE
 TENERIFFA
 TENNERAIRE
 >WHAT SHIPS SAIL TO LISBON AND DO NOT CARRY CONSTRUCTION
 170 MATERIALS?
 TENNESSEE
 TENNERAIRE

In line 1, two individual nouns are conjoined through AND, in line 4 an individual and a class.

Line 11 contains the quantifier ANY and conjunction of two individuals. The ANY quantifier, which works like SOME, results in YES/NO answers. In line 14, the two conjoined individuals are with the WHAT quantifier, and in line 25 with HOW MANY.

Line 28 has three individuals conjoined by OR with the THERE construction.

Line 33 conjoins two relations (attributes) with AND; line 41 has three relations conjoined with AND; line 63 contains four relations conjoined with AND.

It should be noted that in cases where more than two data items are conjoined, all but the last two are separated by commas. This format can easily be changed if a different one is desired, e.g. DESTINATION AND PERCENT FUEL AND ENDURANCE as an alternate to line 41 by introducing a rule of grammar with the desired format.

Line 78 illustrates conjunction of two relations through AND and two individuals through OR in the same sentence. Line 87 is quite similar but contains three conjoint relations. What is of note in the answer, lines 89-102, is the folding of lines which would be too long.

In line 103 two relative clauses are conjoined, each starting with WHICH and containing regular verbs.

In the case of conjunctions of relative clauses, the answer consists of those data items which satisfy conditions specified by both relative clauses.

Line 107 introduces the conjunction of two relative clauses, one of which starts with WHOSE and the second one with WHICH. The clause with WHOSE has a different subject. Line 111 is similar, but the relative conjunction in the second clause is THAT. The question is of the yes/no type with THERE.

In line 114, which contains again a conjunction of two relative clauses, the first of those starts with WHICH and the second with WHOSE followed by a different subject.

Line 118 has two conjoint relative clauses, the first starting with THAT and the second with WHICH.

Line 121 contains a conjunction of three relations and two relative clauses, both of which start with the relative pronoun WHICH. The first relative clause is of a different construction than those exemplified so far.

Lines 125 and 128 contain further examples of conjunctions of relative clauses.

In line 136, the yes/no question with conjoined relative clauses yields both the YES and NO answers due to the listing caused by the EACH quantifier.

Line 140 is an example of conjunction of two regular verbs joined by OR. Line 143 contains both conjunction of two verbs and two individual nouns. The conjunction word is OR in both cases.

In line 159 extended verb phrases are conjoined by AND, and in line 162 they are conjoined by OR. In the first case, the answer consists of that data item which satisfies both conditions simultaneously; in the second case, data items satisfying both conditions independently are listed. Line 169 contains two conjoined extended verb phrases, one of which is negative, conjoined by AND. This results in the listing of those data items which satisfy the conditions in both verb phrases simultaneously.

D-3. PRONOUNS AND OTHER FORMS OF REFERENCE

Pronouns constitute a very powerful means of achieving fluency and economy in discourse. They are also however a notorious source of ambiguity and therefore difficulty in handling. In current REL English, some problems still remain unsolved, and some sentences similar to those illustrated may not work. Also, some cases are not implemented yet.

The processing of pronouns is quite complex, and the user cannot be burdened with those aspects. It may be helpful, however, to know that potential pronoun referents are retained over three sentences, and that the data item which turns out to be the referent continues to be treated as a potential referent. Thus, in line 3 KITTYHAWK is the referent of ITS, and it is retained as a potential referent for future sentences, so that in lines 5, 7, and 9 it is also the referent.

Pronouns can be used in the subject form as in line 5 (IT), the possessive form as in line 3 (ITS), in the animate subject form as in line 24 (HE), and in the possessive animate form (HIS) as in lines 13, 15, and 22. Pronouns can also be used in the plural form, where the animate/inanimate distinction is irrelevant. The subject plural THEY appears in line 33; the possessive plural THEIR in lines 65, 79, 105, 157; the object plural THEM in lines 132, 143, 168, 174. This latter is used with quantifiers such as EACH and WHICH.

The animate/inanimate distinction can best be observed in lines 11-18, where the possessive HIS refers to the person and the possessive ITS to the ship.

Other forms of reference are also used in the examples. The demonstrative THAT and plural THOSE which refer to previously mentioned data items are found in lines 95, 97, 42, and 56.

OTHER, which selects data items of the same class but not those which had been most recently mentioned, is exemplified in lines 76, 92, 99, 111. How it works is easy to see from the sequence in lines 86-112. In line 99 all the OTHER aircraft carriers but KITTYHAWK are referred to, and in line 111 the OTHER aircraft carrier is again, in turn, KITTYHAWK.

The pronominal THAT which refers to a simple relation previously

mentioned or the result of some operations carried out on relations is illustrated in lines 115-135. In line 121 an operation is performed on two relations, and lines 124 and 125 use the result of that calculation.

Pronominal referents can also refer to antecedents within the same sentence, using ITS, HIS, and THAT as illustrated in lines 174-195. At the present time THEIR works in an unsatisfactory manner, or is not yet implemented.

WHAT IS THE DESTINATION OF THE KITTYHAWK?
 NAPLES
 XWHAT IS ITS SPEED?
 20
 5 XDOES IT HAVE A DOCTOR?
 YES
 XWHO IS ITS COMMANDER?
 CAPT R. SPRUANCE
 XWHAT IS ITS HOME PORT AND CALL SIGN?
 10 MAYPORT NABE
 XWHAT IS THE NAME OF THE COMMANDER OF THE SARATOGA?
 CAPT A. BROWN
 XWHAT IS HIS LINEAL?
 4836
 15 XWHAT IS THE DESTINATION OF HIS SHIP?
 6000N X 3000W
 XWHAT IS ITS EMPLOYMENT?
 TENDER RESTRICTED AVAILABILITY
 WHAT IS KNOWN ABOUT CAPT J. KEELY?
 20 HAS A LINEAL
 IS A COMMANDER
 XWHAT IS HIS LINEAL?
 4842
 XWHAT SHIP DOES HE COMMAND?
 25 SOUTH CAROLINA

WHAT COMMANDERS HAVE LINEALS GREATER THAN 101000?

CDR R. DAUGHERTY

CDR J. HIGH

CDR X. COHEN

30 CDR J. HORNER

CDR M. MORTON

CDR T. CHANDLER

>WHAT SHIPS DO THEY COMMAND?

CDR R. DAUGHERTY GRAYLING

35 CDR J. HIGH TAUTOG

CDR X. COHEN WHALE

CDR J. HORNER POGY

CDR M. MORTON SUNFISH

CDR T. CHANDLER ASPRO

40 THE READINESS OF HOW MANY SHIPS IS NOT CI?

8

>LIST THE REASON FOR EACH OF THOSE SHIPS.

AMERICA OVERHAUL

KITTYHAWK AIR SEARCH RADAR FAILURE

45 STERETT SONAR FAILURE

CHARLES F. ADAMS GUN SYSTEM FAILURE

HOEL GUN SYSTEM FAILURE

CONNOLE SONAR FAILURE

RATHBURNE SONAR FAILURE

50 MEYERKORD SONAR FAILURE

WHAT IS THE NUMBER OF TG25.3 SHIPS WITH EACH CLASSIFICATION?

GUIDED MISSILE LIGHT CRUISER 1

AIRCRAFT CARRIER 1

FRIGATE 2

55 NUCLEAR POWERED ATTACK SUBMARINE 2

>LIST THE CALL SIGN AND HULL NUMBER OF EACH OF THOSE SHIPS.

GUIDED MISSILE LIGHT CRUISER HORNE NABX 30

AIRCRAFT CARRIER KITTYHAWK NABE 63

FRIGATE KNOX NACW 1052

60 ROARK NACX 1053

NUCLEAR POWERED ATTACK SUBMARINE BATON ROUGE NABJ 689

POGY NABP 647

>HOW MANY MERCHANT VESSELS ARE THERE THAT CARRY VANADIUM ORE?

5

65 >WHAT ARE THEIR NAMES AND DESTINATIONS?

MORRIS E. CRAIN WILMINGTON

GREENVILLE VICTORY WILMINGTON

TRUMAN KIMLOW WILMINGTON

SHIPPER WILMINGTON

70 SEAFARER WILMINGTON

WHAT IS THE NAME AND LENGTH OF SOVIET AIRCRAFT CARRIERS?
 LENINGRAD 625
 MOSKVA 625
 KIEV 925
 75 MINSK 925
 WHAT IS THE FLAG AND LENGTH OF OTHER AIRCRAFT CARRIERS?
 UNITED STATES 1039
 1072
 WHAT ARE THEIR NAMES AND LENGTHS?
 80 CONSTELLATION 1072
 SARATOGA 1039
 AMERICA 1072
 KITTYHAWK 1072
 JOHN F. KENNEDY 1072
 85 INDEPENDENCE 1039
 WHAT IS THE TYPE OF EACH TU25.3.2?
 KITTYHAWK AIRCRAFT CARRIER
 BATON ROUGE NUCLEAR POWERED ATTACK SUBMARINE
 KNOX FRIGATE
 90 WHO IS THE COMMANDER OF THE KITTYHAWK?
 CAPT R. SPRUANCE
 WHO IS THE COMMANDER OF EACH OF THE OTHER TU25.3.2 SHIPS?
 BATON ROUGE CDR V. QUIET
 KNOX CDR C. JACKSON
 95 WHAT IS THE LENGTH OF THAT SUBMARINE?
 360
 WHAT IS THE LENGTH OF THAT AIRCRAFT CARRIER?
 1072
 WHO IS THE COMMANDER OF EACH OF THE OTHER AIRCRAFT CARRIERS?
 100 CONSTELLATION CAPT J. ELLISON
 SARATOGA CAPT A. BROWN
 AMERICA CAPT W. HALSEY
 JOHN F. KENNEDY CAPT P. MOFFETT
 INDEPENDENCE CAPT S. JACKSON
 105 WHAT ARE THEIR DESTINATIONS?
 UNKNOWN
 NORFOLK
 NAPLES
 6000N X 3000W
 110 3700N X 1700E
 WHAT IS THE OTHER AIRCRAFT CARRIER?
 KITTYHAWK
 WHAT IS ITS DESTINATION?
 NAPLES

115 WHAT IS THE PERCENT FUEL OF THE KNOX?
 90
 >WHAT IS THAT OF THE ROARK?
 88
 >IS THAT OF SOME KNOX CLASS SHIP LESS THAN 80?
 120 YES
 WHAT IS THE RANGE DIVIDED BY NORMAL CRUISING SPEED OF THE
 >KITTYHAWK?
 750
 >WHAT IS THAT OF THE KNOX?
 125 312.5
 >IS THAT OF SOME KNOX CLASS SHIP LESS THAN 300?
 NO
 WHAT IS AMERICA'S REASON?
 OVERHAUL
 130 >WHAT IS THAT OF EACH SHIP WHOSE READINESS IS C3?
 STERETT SONAR FAILURE
 CHARLES F. ADAMS GUN SYSTEM FAILURE
 CONNOLLY SONAR FAILURE
 RATHBURN SONAR FAILURE
 135 MEYERKORD SONAR FAILURE
 HOW MANY NUCLEAR POWERED ATTACK SUBMARINES ARE THERE?
 10
 >WHAT IS THE HULL NUMBER AND CALL SIGN OF EACH OF THEM?
 STURGEON 637 NABL
 140 PHILADELPHIA 690 NABK
 BATON ROUGE 689 NABJ
 LOS ANGELES 688 NABI
 POBY 647 NABP
 GRAYLING 646 NABO
 145 TAUTOG 639 NABN
 WHALE 638 NABM
 ASPRO 648 NABQ
 SUNFISH 649 NABR
 >WHICH OF THEM ARE STURGEON CLASS SHIPS?
 150 STURGEON
 POBY
 GRAYLING
 TAUTOG
 WHALE
 155 ASPRO
 SUNFISH
 >WHAT ARE THEIR EMPLOYMENTS?
 STURGEON ROUTINE MAINTENANCE
 POBY ANTI-SHIPING OPERATIONS
 160 GRAYLING ROUTINE MAINTENANCE
 TAUTOG ROUTINE MAINTENANCE
 WHALE ROUTINE MAINTENANCE
 ASPRO SURVEILLANCE OPERATIONS
 SUNFISH SURVEILLANCE OPERATIONS

- 165 ARE THERE MERCHANT VESSELS THAT CARRY VANADIUM ORE AND
 >WHOSE DESTINATION IS WILMINGTON?
 YES
 >WHICH OF THEM?
 MORRIS E. CRAIN
- 170 GREENVILLE VICTORY
 TRUMAN KIMLOW
 SHIPPER
 SEAFARER
 >WHAT IS THE NUMBER OF THEM?
- 175 5
 DOES THE KITTYHAWK'S NORMAL CRUISING RANGE EXCEED ITS
 >MAXIMUM CRUISING RANGE?
 YES
 >IS THE HULL NUMBER OF CDR C. JACKSON'S SHIP THE SAME
 180 >AS HIS LINEAL?
 NO
 >THE SPEED OF WHAT SUBMARINES IS HIGHER THAN THAT
 >OF THE ASPRO?
 USSR 17
- 185 IS THE PERCENT FUEL OF THE KITTYHAWK EQUIVALENT TO THAT
 >OF EACH OF THE OTHER AIRCRAFT CARRIERS?
- | | | |
|-----|-----------------|-----|
| | CONSTELLATION | NO |
| | SARATOGA | NO |
| | AMERICA | NO |
| 190 | JOHN F. KENNEDY | NO |
| | INDEPENDENCE | NO |
| | LENINGRAD | NO |
| | MOSKVA | YES |
| | KIEV | YES |
| 195 | MINSK | NO |

D-4. COMPARISONS

Comparisons are relatively simple, and they had already been used in previous protocols without any introduction.

The examples that follow illustrate comparisons in more complex sentences, comparisons used with operators such as MAXIMUM, and the variety of comparator terms that can be employed.

Comparisons fall into three groups with the basic meanings GREATER, LESS, AND EQUAL. Conjoined phrases with OR are possible -- such as GREATER THAN OR EQUAL TO and LESS THAN OR EQUAL TO, but not such as "greater than or less than." Negation of comparisons can be used by combining a given word or phrase with NOT, thus NOT GREATER THAN, NOT AS HIGH AS.

The examples in the protocol include several comparators, but they do not exhaust the ones that can currently be used. HIGHER THAN, EQUIVALENT TO, AS GREAT AS, AS LITTLE AS are not found in the examples. There are also only a few combinations with OR and a few negations.

GREATER THAN is illustrated in line 1, EQUAL TO in line 3, LESS THAN in line 7. In these questions the comparative is either in a relative clause (line 1) or in the WITH-phrase equivalent to a relative clause (line 3 and 7). This is also the case in lines 9, 14, 17, and 22. The comparators are LESS THAN OR EQUAL in line 9, AT LEAST in line 14, and both GREATER THAN and EQUAL TO in line 17. The first of these is in an embedded WITH phrase. In line 22 NOT LESS THAN is in an embedded WITH phrase.

THE SAME AS is found in lines 34 and 37, in the latter case in a sentence with a pronoun.

In line 40 the comparator EQUAL TO is used with the MAXIMUM operator. (It will be noticed that the word MAXIMUM also appears in line 37, but there it is part of the vocabulary item, not an operator.)

In line 43 the comparator EXCEED is found with the MAXIMUM operator. EQUAL is in line 46. Two MAXIMUM operators are employed in this example. MAXIMUM is compared with MINIMUM in line 49.

In line 52, EXCEED is again used, with MAXIMUM operators and pronominal OTHER. In line 64, EXCEED is employed in a complex sentence with two relative clauses and the verb DO.

In line 70 the comparators AT LEAST and the negative NOT EQUAL TO both appear. The negative NOT LESS THAN is in line 73.

The comparator MORE THAN is in lines 77 and 80, in the latter in a command sentence starting with LIST.

The subsequent several lines illustrate the case of other comparators. AS HIGH AS is in line 87, AS MUCH AS in 89, AS LOW AS in 91, AT MOST in 93.

Lines 98 and 101 contain MORE THAN which was found earlier in lines 77 and 80. But it should be noted that the construction is different here. In lines 77 and 80, MORE THAN was followed by a number alone, while in line 98 it is followed by a number and a noun -- thus MORE THAN 80 as against MORE THAN 7 SHIPS.

Lines 101 and 104 draw attention to the fact that numbers can appear as figures such as 10 as well as spelled as TEN.

In the remaining lines the comparators OVER and UNDER are used in similar ways as MORE THAN in two types of constructions in lines 77 and 80 on the one hand and 98 and 101 on the other. In line 105, OVER is followed by a number alone, in line 110 by a number and a noun -- thus OVER 49 as against OVER 70 SHIPS. Similarly, in line 108, UNDER 10 is found as against UNDER 300 SHIPS in line 112.

The comparator EXACTLY is illustrated in line 114, followed by a spelled out number and a noun phrase.

ARE THERE SHIPS WHOSE SPEEDS ARE GREATER THAN 15?

YES

>WHAT ARE KAZBEK CLASS SHIPS WITH SPEED EQUAL TO 10?

ALATYR

5 ANDREY

DENA

>HOW MANY SHIPS WITH PERCENT FUEL LESS THAN 70 ARE THERE?

15

>WHAT IS THE PERCENT FUEL OF EACH SHIP WITH PERCENT FUEL

10 >LESS THAN OR EQUAL TO 40?

AMERICA 0

PROVORNY 40

ANDREY 40

>ARE THERE ANY AIRCRAFT CARRIERS WHOSE ENDURANCE IS

15 >AT LEAST 50?

YES

>WHAT SHIPS WITH PERCENT FUEL GREATER THAN 90 HAVE

>MAXIMUM CRUISING RANGE EQUAL TO 4000?

CONSTELLATION

20 SARATOGA

INDEPENDENCE

>WHAT DOES EACH SHIP WITH PERCENT FUEL NOT LESS THAN

>80 DO?

THERE ARE 40 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?

25 RESPOND WITH "ALL", "NONE", OR A NUMBER.

>7

CONSTELLATION SURVEILLANCE OPERATIONS

SARATOGA TENDER RESTRICTED AVAILABILITY

KITTYHAWK SURVEILLANCE OPERATIONS

30 JOHN F. KENNEDY SURVEILLANCE OPERATIONS

INDEPENDENCE TENDER RESTRICTED AVAILABILITY

STURGEON ROUTINE MAINTENANCE

PHILADELPHIA ANTI-SUBMARINE OPERATIONS

>IS THE ENDURANCE OF SOME SUBMARINE THE SAME AS THE

35 >ENDURANCE OF THE KITTYHAWK?

NO

>IS THE MAXIMUM CRUISING SPEED OF THE CONSTELLATION

>THE SAME AS ITS SPEED?

NO

40 >DOES SOME AIRCRAFT CARRIER HAVE PERCENT FUEL EQUAL TO

>THE MAXIMUM PERCENT FUEL OF SHIPS IN TG67.3?

YES

>DOES THE LENGTH OF ANY TANKER EXCEED THE MAXIMUM

>LENGTH OF AIRCRAFT CARRIERS?

45 NO

>DOES THE MAXIMUM LENGTH OF SOVIET AIRCRAFT CARRIERS

>EQUAL THE MAXIMUM LENGTH OF AIRCRAFT CARRIERS?

NO

- IS THE MAXIMUM LENGTH OF SOVIET AIRCRAFT CARRIERS<
 50 >LESS THAN THE MINIMUM LENGTH OF US AIRCRAFT CARRIERS?
 YES
 >DOES THE KITTYHAWK'S MAXIMUM CRUISING RANGE EXCEED<
 >THE MAXIMUM CRUISING RANGE OF EACH OF THE OTHER<
 >AIRCRAFT CARRIERS?
- 55 CONSTELLATION NO
 SARATOGA NO
 AMERICA NO
 JOHN F. KENNEDY NO
 INDEPENDENCE NO
- 60 LENINGRAD YES
 MOSKVA YES
 KIEV YES
 MINSK YES
- THE ENDURANCES OF WHAT SUBMARINES WHICH DO ANTI-SUB-<
 65 >MARINE OPERATIONS EXCEED THE ENDURANCES OF SUBMARINES<
 >WHICH DO ANTI-SHIPING OPERATIONS?
 PHILADELPHIA
 BATON ROUGE
 LOS ANGELES
- 70 >WHAT SHIPS IN TG67.1 WHOSE ENDURANCE IS AT LEAST 50<
 >HAVE PERCENT FUEL NOT EQUAL TO 100?
 ASHTABULA
 >WHO COMMANDS EACH SUBMARINE WHOSE SPEED IS NOT LESS<
 >THAN 7?
- 75 ASPRO CDR T. CHANDLER
 SUNFISH CDR M. MORTON
 >HOW MANY SUBMARINES ARE THERE WHOSE ENDURANCE IS MORE<
 >THAN 90?
 10
- 80 >LIST THE READINESS AND EMPLOYMENT OF EACH AIRCRAFT<
 >CARRIER WHOSE PERCENT FUEL IS MORE THAN 80.
 CONSTELLATION C1 SURVEILLANCE OPERATIONS
 SARATOGA C1 TENDER RESTRICTED AVAILABILITY
 KITTYHAWK C2 SURVEILLANCE OPERATIONS
- 85 JOHN F. KENNEDY C1 SURVEILLANCE OPERATIONS
 INDEPENDENCE C1 TENDER RESTRICTED AVAILABILITY
 >IS THE CONSTELLATION'S ENDURANCE AS HIGH AS 70?
 NO
 >IS THE KITTYHAWK'S PERCENT FUEL AS MUCH AS 90?
- 90 NO
 >IS THE PERCENT FUEL OF ANY SHIP AS LOW AS 10?
 YES

>DO AT MOST TWO SHIPS CARRY GENERAL MERCHANDISE?
YES
95 >DO AT LEAST 5 SHIPS WHICH CARRY OIL BELONG TO
>THE UNITED KINGDOM?
YES
>DO MORE THAN 7 SHIPS THAT DEPARTED NEW YORK BELONG
>TO THE UNITED STATES?
100 NO
>ARE THERE MORE THAN TEN SHIPS WHICH CARRY COAL?
NO
>DO LESS THAN 10 SHIPS APPROACH NAPLES?
YES
105 >IS THE NUMBER OF AIRCRAFT CARRIERS OVER 49?
NO
>IS THE NUMBER OF SHIPS THAT CARRY CHROME ORE
>UNDER 10?
YES
110 >ARE THERE OVER 70 SHIPS?
YES
>ARE THERE UNDER 300 SHIPS?
YES
>ARE THERE EXACTLY TEN US SUBMARINES?
115 YES

E. VERBS

We distinguish between verbs BE and HAVE on the one hand and verbs such as COMMAND or DEPART which we call regular verbs on the other. BE and HAVE exist in the rules of REL English grammar. Regular verbs are introduced by definition. The definitions are in the form of a paraphrase in which the meaning is assigned to the verb on the basis of some relation. Meanings of verbs thus depend highly on the relation that is used in the paraphrase. This situation parallels the one in ordinary English where the meaning of verbs is highly dependent on context. As an example, the verb TAKE has vastly different meanings depending on whether the discourse is about "TAKING a book from the shelf," "TAKING a science course," "TAKING a shower," or "TAKING a northbound course."

A simple example of a verb definition by paraphrase is the one below.

**VERB:OFFICERS "COMMAND" SHIPS:OFFICERS ARE COMMANDERS OF SHIPS
DEFINED.**

The verb COMMAND is simply defined in terms of the relation COMMANDER. Usually, however, the paraphrase is more complex, as will be seen from definitions in a subsequent protocol.

Verbs can also be defined in terms of other verbs.

In general, the relation word or other verb which appears on the right-hand side in the definition must be known to the system, as must be the other words, both on the left and right sides (except, of course, the verb which is being defined). Moreover, the words on both sides must match and they must be in the same order. Thus, COMMANDER is a relation known to the system, as are the nouns OFFICER and SHIP. OFFICER and SHIP are in the same order on both sides. If the order were changed, e.g. to COMMANDERS OF SHIPS ARE OFFICERS on the right-hand side, problems might arise, with the reasons for which the user will not be burdened.

The verb that is being defined must be placed between double quotation marks, and must appear in its dictionary form, that is,

without any endings. The case of verbs which are introduced in the singular, i.e. with S following the verb, and the case of the verbs which require special spellings are discussed when such definitions are introduced in the second protocol.

The nouns which are used in a definition, such as OFFICER and SHIP in the above definition, are only place holders, as it were, for other nouns which make sense in a given context. Thus in line 3 of the protocol below which illustrates some uses of the verb COMMAND that has just been defined, the nouns CAPT R. SPRUANCE and KITTYHAWK are substituted for the original OFFICER and SHIP. In line 5, it is likewise CDR C. JACKSON and TAPU, the order being reversed here because of the passive construction IS Y COMMANDED BY X, which is equivalent to X COMMANDS Y.

Forms such as COMMANDS in line 1, 7, 17, that is the regular singular forms, are handled by rules of grammar. Irregular forms such as CARRIES require an additional definition. This is treated in lines 41 and 48 of the second protocol.

Passive forms of verbs (lines 5 and 14) are also handled by rules of grammar. If the form of the verb is irregular, such as CARRIED, an additional definition has to be made use of, the same as for handling CARRIES.

In line 17 COMMANDS is found within a relative clause.

```

WHO COMMANDS THE KNOX?
  CDR C. JACKSON
> DOES CAPT R. SPRUANCE COMMAND THE KITTYHAWK?
  YES
5 > IS TAPU COMMANDED BY CDR C. JACKSON?
  NO
  > WHO COMMANDS EACH US AIRCRAFT CARRIER?
  CONSTELLATION CAPT J. ELLISON
  SARATOGA CAPT A. BROWN
10 AMERICA CAPT W. HALSEY
  KITTYHAWK CAPT R. SPRUANCE
  JOHN F. KENNEDY CAPT P. MOFFETT
  INDEPENDENCE CAPT S. JACKSON
  > WHAT SHIP IS COMMANDED BY CDR C. SNEAK?
15 PHILADELPHIA
  > WHAT IS THE DESTINATION OF THE SHIP THAT CAPT P. MOFFETT
  > COMMANDS?
  NORFOLK

```

Negation of verbs can be used, and an example is found at the very end of the last protocol.

In the next protocol several verb definitions are introduced. In line 1 DEPART is defined in terms of the relation DEPARTURE POINT. It will be noticed that even though DEPARTURE POINT is the first term on the right-hand side, the order of SHIPS MAYPORT is the same on both sides.

CARRY is defined in line 4 in terms of CARGO TYPE. The format is the same as in the case of DEPART.

OWN in line 6 is defined in terms of FLAG, which is a specific meaning to this data base. The format here is different than in the case of DEPART and CARRY since the order NORWAY TARU has to be preserved. Here, as in line 8 for SIGNAL, the verb is introduced in the singular form. The verb is placed between double quotes as usual and the S for the singular form immediately follows. A verb defined in this way can equally well be used without the S in other forms, e.g. past or passive OWNED.

SIGNAL is defined in terms of CALL SIGN in line 8 in keeping with the meaning in this data base. The format is the same as in the case of OWN.

APPROACH in line 11, SAIL TO in line 17, SAIL FOR in line 19, and MOVE TOWARDS in line 26 are all defined in terms of DESTINATION, which was the only suitable relation in the data base. These examples illustrate two points: the possibility of using synonyms and prepositions as part of the verb.

In lines 21 and 29, SAIL FROM and MOVE AWAY FROM are similarly defined as synonymous with DEPART, since they are defined in terms of the relation DEPARTURE POINT.

In line 14 the verb DO is defined in terms of EMPLOYMENT, which again is the only suitable attribute in the data base.

BELONG TO in line 24 is defined similarly as OWN in line 6 in terms of FLAG, but the order is reversed here.

Lines 32 and 34 illustrate verbs defined in terms of number relations: MEASURE in terms of length and STEAM AT in terms of SPEED.

The noun SHIP and the numbers could of course be substituted by others.

The next three definitions, lines 36, 38, and 41, deal with irregular forms of verbs. The definition of CARRIE in line 36, which is identical, as would be expected, to that of CARRY, allows this form to be used in CARRIES and CARRIED. Similarly, APPROACHE in line 38 allows APPROACHES and APPROACHED (although the latter is also handled by grammar rules, like COMMANDED).

Line 41 introduces SIGNALL as an alternate spelling of SIGNAL which can be used in SIGNALLED, and also illustrates how a verb in singular form can be defined -- the verb is placed between double quotes as usual, and S follows immediately.

Lines 44 and 46 illustrate definition of verbs as synonymous with other verbs. TRANSPORT is defined as a synonym of CARRY and CRUISE AT as a synonym of STEAM AT.

Line 48 shows how a verb in singular can be introduced if the verb is followed by a preposition. As will be noticed the verb part is CRUISES. Thus, in case a preposition follows, both forms of verbs, such as singular in line 48 CRUISES AT and plural in line 46 CRUISE AT, have to be defined separately.

Examples in lines 50, 53, 55, and 57 illustrate the use of irregular verb forms introduced by definitions above. Lines 53 and 57 are in the passive form.

```

VERB:SHIPS "DEPART" MAYPORT:DEPARTURE POINT OF SHIPS
>IS MAYPORT
  DEFINED.
>VERB:SHIPS "CARRY" COAL:CARGO TYPE OF SHIPS IS COAL
5  DEFINED.
>VERB:NORWAY "OWN" S TARU:NORWAY IS THE FLAG OF TARU
  DEFINED.
>VERB:NABG "SIGNAL" S THE SARATOGA:NABG IS THE CALL SIGN
>OF THE SARATOGA
10  DEFINED.
>VERB:SHIPS "APPROACH" NAPLES:DESTINATION OF SHIPS IS
>NAPLES
  DEFINED.
>VERB:SHIPS "DO" ANTI-SUBMARINE OPERATIONS:THE EMPLOY-
15>MENT OF SHIPS IS ANTI-SUBMARINE OPERATIONS
  DEFINED.

```

>VERB: SHIPS "SAIL TO" NAPLES: DESTINATION OF SHIPS IS NAPLES
 "DEFINED."
 >VERB: SHIPS "SAIL FOR" NAPLES: DESTINATION OF SHIPS IS NAPLES
 20 "DEFINED."
 >VERB: SHIPS "SAIL FROM" NAPLES: DEPARTURE POINT OF SHIPS IS
 NAPLES
 "DEFINED."
 >VERB: SHIPS "BELONG TO" NORWAY: FLAG OF SHIPS IS NORWAY
 25 "DEFINED."
 >VERB: SHIPS "MOVE TOWARDS" LONDON: DESTINATION OF SHIPS
 IS LONDON
 "DEFINED."
 >VERB: SHIPS "MOVE AWAY FROM" LONDON: DEPARTURE POINT OF
 30 SHIPS IS LONDON
 "DEFINED."
 >VERB: SHIPS "MEASURE" 500: LENGTH OF SHIPS IS 500
 "DEFINED."
 >VERB: SHIPS "STEAM AT" 20: SPEED OF SHIPS IS 20
 35 "DEFINED."
 >VERB: SHIPS "CARRIE" COAL: CARGO TYPE OF SHIPS IS COAL
 "DEFINED."
 >VERB: SHIPS "APPROACHE" NAPLES: DESTINATION OF SHIPS
 IS NAPLES
 40 "DEFINED."
 >VERB: NABG "SIGNAL" SARATOGA: NABG IS THE CALL SIGN OF
 SARATOGA
 "DEFINED."
 >VERB: SHIPS "TRANSPORT" COAL: SHIPS CARRY COAL
 45 "DEFINED."
 >VERB: SHIPS "CRUISE AT" 20: SHIPS STEAM AT 20
 "DEFINED."
 >VERB: SHIP "CRUISES AT" 20: THE SPEED OF SHIP IS 20
 "DEFINED."
 50 >WHICH SUBMARINE CRUISES AT 8 ?
 ASPRO
 SUNFISH
 ARE CONSTRUCTION MATERIALS CARRIED BY SOME NORWEGIAN SHIP?
 YES
 55 >WHAT SHIP APPROACHES LONDON?
 TALLEYRAND
 >IS THE KITTYHAWK SIGNALLED BY NABD?
 NO

Examples of a variety of sentences containing verbs are provided in the next protocol. Several sentences with verbs are also found in previous sections.

For the most part, the sentences here are self-evident. However, a few comments may bring out some interesting structural possibilities.

Most verbs which appear in this book are either in present or past tense. This is due to the nature of the data base which does not contain time information. However, REL English does allow the use of tenses and time information, as was shown in Chapter C.

Line 1 contains CARRY followed by the object AIRCRAFT, and the quantifier WHICH.

In line 6 the object is inquired about with WHAT. It will be noticed that WHAT is not followed by a noun here as it is in line 12, WHAT SHIPS.

Line 8 contains the ANY quantifier and is a yes/no question.

Line 10 has the verb DEPARTED, in past tense, and the HOW MANY quantifier.

Line 12 contains APPROACH.

In line 16 the verb is in the discontinuous form HAS . . . DEPARTED.

Line 18 has the verb SIGNALS. It will be noticed that the S is here combined with the verb SIGNAL which was defined in the previous protocol in line 8 and not in line 41.

Line 21 contains the verb TRANSPORT which had been defined in terms of CARRY (line 44 of the previous protocol), and the EACH quantifier.

Line 30 has APPROACH in passive and the AT LEAST quantifier.

Line 35 has both the HOW MANY and EACH quantifiers which result in the expected listing.

The verb DO is used in line 53.

Line 58 contains the verb CRUISE AT which was defined in terms of the verb STEAM AT, which in turn was defined on the basis of the number relation SPEED (lines 46 and 34 of the previous protocol).

The operator MAXIMUM is also used here, as well as in line 63 below, where the verb is also defined in terms of the number relation LENGTH (line 32 of the previous protocol).

Conjunctions of verbs can be used, which is illustrated in line 74. The two verbs are first used singly: SAIL FROM (which is synonymous with DEPART) in line 69 and SAIL TO (synonymous with APPROACH) in line 72. The conjunction is OR and therefore the answer consists of entities which satisfy either of the conditions.

Verb phrases such as DEPARTED SOME EUROPEAN PORT in line 78 can be conjoined with other verb phrases, as shown in that line. The conjunction is AND, therefore the answer consists of only those entities which satisfy both conditions.

Line 90 contains two verbs, one in the passive form, ARE . . . TRANSPORTED, and another, OWNS, in the relative clause. The OR conjunction of nouns results in the NO and YES answers for the entities involved.

Line 94 also contains two verbs, COMMANDS in the relative embedded clause and the verb DO in the main sentence.

In line 96 the passive is in the form HAS . . . BEEN DEPARTED, and the verb BELONG TO (which had been defined in terms of the FLAG relation) is in the final relative clause.

Line 98 has the verb SAIL FOR which is synonymous with APPROACH, followed by a noun phrase with the conjunction OR which is in the embedded relative clause, and the verb CARRY in the main sentence. The presence of the EACH quantifier causes the names of the ships to be listed.

In line 105 the LIST command is used. It will be noticed that since EACH is not used, the names of the ships do not appear.

Line 117 has two occurrences of OWN. The one in the embedded relative clause singles out only those countries which own ships, thus eliminating from the listing countries which own zero merchant vessels.

Line 127 contains a passive and a past tense.

In line 130 the passive is in the past tense, WAS . . . DEPARTED, and CARRY is followed by a conjoined noun phrase with OR.

Line 134 has two verbs, CARRY and DEPARTED, each in a relative clause which are conjoined. Due to the AND conjunction only entities which satisfy both conditions are listed.

In line 156 both verbs are in the singular and APPROACHES arises from the special spelling definition of APPROACHE (line 38 of the previous protocol).

Line 159 is synonymous with line 74.

The next four examples employ verbs defined in terms of number relations.

Line 163 is a complex sentence in which the embedded relative clause has the verb MEASURES with a comparison. The object is inquired about, and the subject contains the EACH quantifier.

In line 168 the seemingly simpler sentence is similar to line 163 but it does not contain the EACH quantifier.

Line 170 has the command LIST followed by a conjunction of four nouns, and the verb STEAM AT followed by a comparison in the relative clause.

Line 174 contains two conjoined verb phrases. The first illustrates the use of verb negation, DO NOT STEAM AT, and the second contains the verb HAVE with a negative comparison.

```

WHICH NORWEGIAN SHIPS CARRY AIRCRAFT?
TASCO
TARU
TARIFA
5 TENNESSEE
>WHAT DO LIBERIAN SHIPS CARRY?
OIL
>DO ANY US MERCHANT VESSELS CARRY OIL?
YES
10 >HOW MANY SHIPS DEPARTED RIGA?
2
>WHAT SHIPS APPROACH ALEXANDRIA?
TASCO
TAURUS
15 TERNA
>HAS THE TARU DEPARTED RIGA?
YES
>WHAT SIGNALS THE KNOX AND THE SUNFISH?
SUNFISH NABR
20 KNOX NACW

```

- WHAT DOES EACH WEST GERMAN SHIP TRANSPORT?
- TRANSPACIFIC AMMUNITION
- TRANSGERMANIA AMMUNITION
- TRANSEUROPA AIRCRAFT
- 25 TRANSCANADA AIRCRAFT
- TRANSATLANTIC AIRCRAFT
- TRANSAMERICA TANKS
- POSEIDON TANKS
- TRANSQUEBEC AMMUNITION
- 30 WHAT EUROPEAN PORTS ARE APPROACHED BY AT LEAST THREE SHIPS?
- NAPLES
- OSLO
- LIVERPOOL
- LISBON
- 35 HOW MANY SHIPS CARRY EACH CARGO?
- UNKNOWN 1
- PHOSPHATES 1
- TUNGSTEN 6
- AMMUNITION 4
- 40 AIRCRAFT 9
- TANKS 6
- TRUCKS 2
- FARM MACHINERY 3
- TIN 3
- 45 CHROME ORE 8
- VANADIUM ORE 5
- COAL 4
- WHEAT 6
- OIL 40
- 50 GENERAL FOODS 6
- CONSTRUCTION MATERIALS 4
- GENERAL MERCHANDISE 2
- WHAT DO SUBMARINES DO?
- ROUTINE MAINTENANCE
- 55 SURVEILLANCE OPERATIONS
- ANTI-SHIPING OPERATIONS
- ANTI-SUBMARINE OPERATIONS
- WHAT AIRCRAFT CARRIERS CRUISE AT THE MAX SPEED?
- OF AIRCRAFT CARRIERS?
- 60 CONSTELLATION
- KITTYHAWK
- JOHN F. KENNEDY
- WHAT IS THE NAME AND FLAG OF SHIPS WHICH MEASURE THE
- MAXIMUM OF THE LENGTHS OF SHIPS?
- 65 CONSTELLATION UNITED STATES
- AMERICA UNITED STATES
- KITTYHAWK UNITED STATES
- JOHN F. KENNEDY UNITED STATES

>WHAT SHIPS SAIL FROM LONDON?
 70 TAMPA
 TAMESIS
 >WHAT SHIPS SAIL TO LONDON?
 TALLEYRAND
 >WHAT SHIPS SAIL FROM OR SAIL TO LONDON?
 75 TAMPA
 TAMESIS
 TALLEYRAND
 >WHAT SHIPS DEPARTED SOME US PORT AND SAIL FOR SOME
 >EUROPEAN PORT?
 80 THERE ARE 55 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
 RESPOND WITH "ALL", "NONE", OR A NUMBER.
 >7
 HOEL
 ROBISON
 85 SELLERS
 TOWERS
 LYNDE B. MCCORMICK
 ADELAIDE STAR
 AMERICA STAR
 90 ARE WHEAT OR GENERAL FOODS TRANSPORTED BY SOME SHIP
 >THAT NORWAY OWNS?
 WHEAT NO
 GENERAL FOODS YES
 >WHAT DOES THE SHIP WHICH CAPT. J. HORNER COMMANDS DO?
 95 ANTI-SHIPING OPERATIONS
 >HAS RIGA BEEN DEPARTED BY SHIPS THAT BELONG TO US?
 NO
 WHAT DOES EACH OF THE MERCHANT VESSELS WHICH SAIL FOR
 >LUANDA OR ALEXANDRIA CARRY?
 100 ALEXANDRIA TASCO AIRCRAFT
 TAURUS TANKS
 TERNA AIRCRAFT
 LUANDA TARU AIRCRAFT
 TARANTEO TANKS
 105 >LIST THE CARGO AND CALL SIGN OF SHIPS THAT BELONG
 >TO SOUTH AFRICA.
 TUNGSTEN P3A8
 P3A7
 P3A6
 110 CHROME ORE P3A2
 P3A3
 P3B0
 P3A9
 P3B1
 115 VANADIUM ORE P3A5
 P3A4

>HOW MANY MERCHANT VESSELS DOES EACH COUNTRY THAT <
 >OWNS SHIPS OWN?
 UNITED STATES 26
 120 SOVIET UNION 0
 LIBERIA 5
 NORWAY 20
 WEST GERMANY 8
 SOUTH AFRICA 10
 125 NETHERLANDS 10
 UNITED KINGDOM 31
 >IS VANADIUM ORE TRANSPORTED BY SHIPS WHICH DEPARTED <
 >LUANDA?
 YES
 130 >WAS SOME EUROPEAN PORT DEPARTED BY SHIPS WHICH CARRY <
 >WHEAT OR COAL?
 COAL NO
 WHEAT NO
 >LIST THE OWNER OF SHIPS WHICH CARRY EACH CARGO AND <
 135 >WHICH DEPARTED NEW YORK.
 TUNGSTEN NETHERLANDS
 AMMUNITION WEST GERMANY
 UNITED KINGDOM
 AIRCRAFT NORWAY
 140 WEST GERMANY
 UNITED KINGDOM
 TANKS WEST GERMANY
 NETHERLANDS
 UNITED KINGDOM
 145 TRUCKS NETHERLANDS
 UNITED KINGDOM
 FARM MACHINERY NETHERLANDS
 UNITED KINGDOM
 TIN NETHERLANDS
 150 COAL NETHERLANDS
 UNITED KINGDOM
 WHEAT NETHERLANDS
 UNITED KINGDOM
 OIL UNITED KINGDOM
 155 CONSTRUCTION MATERIALS NORWAY
 >WHO COMMANDS THE AIRCRAFT CARRIER WHICH APPROACHES <
 >NORFOLK?
 CAPT P. MOFFETT
 >WHAT SHIPS APPROACH OR DEPART LONDON?
 160 TAMPA
 TAMESIS
 TALLEYRAND

WHAT PORT DOES EACH AIRCRAFT CARRIER WHICH MEASURES
>MORE THAN 1000 APPROACH?
165>CONSTELLATION ... NAPLES
KITTYHAWK ... NAPLES
JOHN F. KENNEDY ... NORFOLK
>WHAT DO SUBMARINES WHICH MEASURE MORE THAN 300 DO?
ANTI-SUBMARINE OPERATIONS
170>LIST THE NAME, SPEED, LONGITUDE AND LATITUDE OF SOVIET
>CRUISERS THAT STEAM AT MORE THAN 10.
ADMIRAL GOLOVKO 15 -2 7259
ADMIRAL FOKIN 15 1 7258
>WHAT SOVIET CRUISERS DO NOT STEAM AT 10 AND HAVE
175>PERCENT FUEL NOT LESS THAN 50?
VARYAG
GROZNY
ADMIRAL GOLOVKO
ADMIRAL FOKIN

F. PARAPHRASE AND DECOMPOSITION

In cases when a given sentence is not understood by the computer, it may be necessary to rephrase it or restate it as a sequence of simpler sentences.

The discussion here is merely illustrative.

As used here, paraphrase refers to expressing the meaning of a given sentence in different words and structures which still result in a single sentence. Decomposition refers to restating a given sentence as a series of sentences. The reasons for paraphrase and decomposition overlap, but in the case of paraphrase, they are mostly that words or linguistic structures (or both) may be unknown to the system. In the case of decomposition, a given sentence, which may even be of simple structure, may require a number of steps in computation, which have to be expressed to the system in a sequence. The distinction is not always completely clear-cut, yet it may be useful to illustrate the two processes separately. As examples of simple paraphrase let us take WHERE IS TARU BOUND? which can be restated as WHAT IS THE DESTINATION OF TARU? and WHAT IS KITTYHAWK DOING? which can be paraphrased as WHAT IS THE EMPLOYMENT OF THE KITTYHAWK?

As an example of what might necessitate decomposition the following question can be considered:

CAN STERETT REACH NORFOLK WITHOUT REFUELING?

The answer will clearly be different depending on whether the Sterett will go at normal or at maximum cruising speed. Let us assume it will be normal speed. What we need to know (for this data base) is:

- (1) That a U.S. naval ship consumes 7 percent of its fuel in 24 hours at its normal speed.
- (2) Where is Sterett?
- (3) What is the distance from that location to Norfolk?

- (4) What is Sterett's normal cruising speed?
- (5) How much fuel does Sterett have?
- (6) How much fuel does Sterett use per hour?

Then we need to compute Sterett's steaming time from where it is to Norfolk, how much fuel it would use in that time, subtract that amount of fuel from its fuel percent, and find out whether that is greater than zero to obtain the answer.

In a situation as complex as this, decomposition of the original question, simple as it may appear to be, is clearly required.

G. ARITHMETIC OPERATIONS AND FUNCTIONS

Normal arithmetic expressions can be used. For example:

```
>WHAT IS 3*(4+5)?
27
>WHAT IS 36.66/3?
12.22
```

The asterisk is used as the multiplication sign. Exponentiation is expressed by double asterisks. Thus the square of 8 (i.e. 8^2) may be expressed as $8^{**}2$. Decimals may be used:

```
>WHAT IS 16.54+4.01**2?
32.6201
>WHAT IS 2**1.5?
1.41421
```

Arithmetic operations may be combined using normal precedence conventions. Thus

```
>WHAT IS 3*4+5?
17
>WHAT IS 3*(4+5)?
27
>WHAT IS 3**2**2?
18
>WHAT IS 3**(2**2)?
81
```

Numbers are always carried to six digit accuracy. Thus

```
>WHAT IS 1.23456?
1.23456
>WHAT IS 1.23456789?
1.23457
```

Very large or very small numbers are expressed using "scientific notation," i.e. a six-digit number followed by a power of 10.

```
>WHAT IS 56789*10000?
5.6789E+08
```

Note that the answer is to be interpreted as:

5.6789×10^8 or 567890000

>WHAT IS 1.2345/10000?
1.2345E-04

Which is to be interpreted as:

12345×10^{-4} or .00012345

Literal numbers through millions may be used.

>WHAT IS ONE THOUSAND NINE HUNDRED AND SEVENTY EIGHT?
1978
>WHAT IS TWO TIMES SEVEN?
14
>WHAT IS THIRTY TO THE POWER 2?
900

Extra spaces are of no consequence.

>IS 3*4 + 5/7 > 3+ 4 +5?
YES

Numbers may arise from nonnumeric expressions. These can be used in arithmetic expressions.

>WHAT IS THE RANGE OF THE KITTYHAWK*25?
300000
>WHAT IS THE NORMAL CRUISING RANGE TIMES PERCENT FUEL OF
>THE KITTYHAWK DIVIDED BY ITS NORMAL CRUISING SPEED?
66000

The usual mathematical functions can be used in normal ways.

>WHAT IS COS(30)?
.866025
>WHAT IS THE SQUARE ROOT OF .64?
.8
>WHAT IS LOG(NUMBER OF AIRCRAFT CARRIERS WHOSE FLAG IS US)?
.778151

The following is a list of the functions that are provided, together with abbreviations which may be used:

ABSOLUTE VALUE (ABS)

SQUARE ROOT (SQRT)

EXPONENTIAL (EXP)

[i.e. the number E to the stated power $\exp(5) = E^5$]

LOGARITHM (LOG, LOG10)

NATURAL LOG (LOGE)

SQUARE (also SQUARED)

CUBIC (also CUBED)

SIN

COS

TAN

COTAN

ARCSIN

ARCCOS

ARCTAN

PI (= 3.14159)

Arithmetic functions and standard operations may be applied when classes are involved. Thus

```
>WHAT IS THE RANGE AND LOG(RANGE) OF TU25.3.2 SHIPS?
12000 4.07918
UNKNOWN UNKNOWN
5000 3.69897
>LIST THE LENGTH AND SQUARE ROOT OF THE LENGTH OF
>EACH SHIP WHOSE CARGO IS TIN.
ANDREW MILLER 455 21.3307
FRANCIS MCGRAW 455 21.3307
AMSTELMOLEN 559 23.6432
```

The simple statistical functions are provided. They, of course, usually take classes as arguments. The following illustrates the various statistical functions:

```

XWHAT IS THE LENGTH OF EACH TU25.3.2 SHIP?
KITTYHAWK    1072
BATON ROUGE  360
KNOX         438
XWHAT IS THE MAXIMUM LENGTH OF TU25.3.2 SHIPS?
1072
XWHAT IS THE MAXIMUM OF THE LENGTHS OF TU25.3.2 SHIPS?
1072
XWHAT IS THE MINIMUM LENGTH OF TU25.3.2 SHIPS?
360
XWHAT IS THE MEAN LENGTH OF TU25.3.2 SHIPS?
623.333
XWHAT IS THE AVERAGE LENGTH OF TU25.3.2 SHIPS?
623.333
XWHAT IS THE SUM OF THE LENGTHS OF TU25.3.2 SHIPS?
1870
XWHAT IS THE TOTAL LENGTH OF TU25.3.2 SHIPS?
1870
XWHAT IS THE PRODUCT OF THE LENGTHS OF TU25.3.2 SHIPS?
1.69033E+08
XWHAT IS THE STANDARD DEVIATION OF THE LENGTHS OF
TU25.3.2 SHIPS?
318.85
XWHAT IS THE VARIANCE OF THE LENGTHS OF TU25.3.2 SHIPS?
101665

```

These of course may be used in combinations:

```

XWHAT IS THE MAX, MIN, MEAN AND STANDARD DEVIATION OF
THE LENGTHS OF TU25.3.2 SHIPS?
1072 360 623.333 318.85
XLIST THE MAXIMUM, MINIMUM AND AVERAGE OF THE LENGTHS
OF AIRCRAFT CARRIERS WITH EACH FLAG.
UNITED STATES 1072 1039 1061
SOVIET UNION 925 625 775

```

H. FORMATTING OF OUTPUT

H-1. THE COMMAND "LIST"

The command LIST, employment of quantifiers (especially multiple ones), and graphic display of data are means available for obtaining tabular listings of data, and of plots and histograms.

The command LIST can be used as an alternate to a question simply to obtain one item of data, for instance LIST THE COMMANDER OF THE KITTYHAWK instead of WHO IS THE COMMANDER OF THE KITTYHAWK?, but this is clearly not where the power of the command lies.

When LIST is used in more complex sentences with conjunctions, quantifiers, or relative clauses extensive tables of output can be produced.

Some of the structural properties of useful sentences are illustrated in the following protocol. Although they had been employed in earlier sections, some comments are provided here.

The LIST command can be used to obtain nonnumerical information, as in line 1, or numerical information, as in line 4, or mixed, as in line 13. In line 1 the conjunction AND is found; in lines 4 and 14 the conjunction AND and the quantifier EACH.

Line 20 illustrates the use of FOR with LIST. FOR and OF are mutually substitutable with LIST. Also illustrated is the elliptical relative construction WITH, which is commonly used with LIST.

Line 34 contains the conjunction AND and quantifier EVERY.

Lines 46 and 49 contain the quantifier ANY and the relative clause with WHOSE. It will be noticed that UNKNOWN is an item of data just like other individuals.

Lines 56 and 67 illustrate the quantifier ALL and contain relative clauses with WHICH and THAT respectively.

Line 71 is a complex sentence with five nouns conjoined by AND, the quantifier EACH, the elliptical WITH phrase with two nouns conjoined by OR, which results in a listing with seven columns.

The next example, line 104, illustrates the situation where the output is too long for being printed in one line and is therefore "folded." The sentence contains three conjoined nouns, the EACH quantifier, and a relative clause which is a negative with NOT.

Lines 122 and 130 are connected, since the pronoun THEM, preceded by the EACH OF quantifier, in line 30 refers to the output obtained through the command in line 122.

Lines 137 and 152 are somewhat similar, since they employ AND and OR conjunctions, the EACH quantifier, and relative clauses. However, in line 137 the OR conjunction applies to two noun items which follow the verb IS, and in line 152 the verb DOES.

Line 162 contains the conjunction of four noun items through AND and of two relative clauses through AND, one starting with WHICH and therefore having the same subject (SHIPS) and one starting with WHOSE with a different subject (DESTINATION). The second relative clause is negative. That many conditions are met by only one ship.

```

LIST THE FLAG, HOME PORT AND CURRENT EMPLOYMENT OF
>THE KITTYHAWK.
UNITED STATES MAYPORT SURVEILLANCE OPERATIONS
>LIST THE ENDURANCE, MAXIMUM CRUISING RANGE AND MAXIMUM
5>CRUISING SPEED OF EACH SHIP IN TG67.1.
KITTYHAWK 45 4000 35
WAINWRIGHT 45 1800 34
WILLIAM H. STANDLEY 45 1800 34
STERETT 45 1800 34
10 HORNE 45 1800 34
JQUETT 45 1800 34
ASHTABULA 60 7000 25
>LIST THE QUANTITY OF CARGO, SPEED, DESTINATION AND
>CALL SIGN OF EACH HIGH-INTEREST SHIP.
15 TASCO 150T 15 ALEXANDRIA K404
TARU 50T 16 LUANDA K403
TARIFA 150T 15 MOCAMEDES K402
TAURUS 150T 15.1 ALEXANDRIA K405
TERNA 150T 15 ALEXANDRIA K406
20 >LIST THE EMPLOYMENT AND DESTINATION FOR EACH SHIP WITH
>PERCENT FUEL GREATER THAN 85.
THERE ARE 38 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
RESPOND WITH "ALL", "NONE", OR A NUMBER.
>9
25 CONSTITUTION SURVEILLANCE OPERATIONS NAPLES
SARATOGA TENDER RESTRICTED AVAILABILITY 6000N X 3000W
KITTYHAWK SURVEILLANCE OPERATIONS NAPLES
JOHN F. KENNEDY SURVEILLANCE OPERATIONS NORFOLK
INDEPENDENCE TENDER RESTRICTED AVAILABILITY 3700N X 1700E
30 STURGEON ROUTINE MAINTENANCE 0N X 4500E
PHILADELPHIA ANTI-SUBMARINE OPERATIONS NORFOLK
BATON ROUGE ANTI-SUBMARINE OPERATIONS NORFOLK
LOS ANGELES ANTI-SUBMARINE OPERATIONS NORFOLK

```

LIST THE HULL NUMBER AND CALL SIGN FOR EVERY AIRCRAFT

35 >CARRIER.

CONSTELLATION	64	NABC
SARATOGA	60	NABG
AMERICA	66	NABF
KITTYHAWK	63	NABE
40 JOHN F. KENNEDY	67	NABD
INDEPENDENCE	62	NABH
LENINGRAD	2	RN04
MOSKVA	1	RN03
KIEV	3	RN02
45 MINSK	4	RN01

>LIST THE HULL NUMBER OF ANY AIRCRAFT CARRIER WHOSE DESTINATION IS UNKNOWN.

AMERICA 66

>LIST THE COMMANDER AND CALL SIGN FOR ANY SHIP IN T667.1

50 >WHOSE DESTINATION IS UNKNOWN.

WAINWRIGHT	CAPT D. EVANS	NABV
WILLIAM H. STANDLEY	CAPT C. MICHAELS	NABZ
STERETT	CAPT W. HOHMANN	NABY
HORNE	CAPT J. BRANIN	NABX
55 JOUETT	CAPT T. FRENZINGER	NABW

>LIST THE CALL SIGN FOR ALL TANKERS WHICH ARE SEALIFT CLASS SHIPS.

ATLANTIC	UA1K
PACIFIC	UA1J
60 ARABIAN SEA	UA1L
ANTARCTIC	UA1R
ARCTIC	UA1P
INDIAN OCEAN	UA1P
CARRIBEAN	UA1D
65 CHINA SEA	UA1N
MEDITERRANEAN	UA1M

>LIST ALL SHIPS THAT CARRY TIN.

ANDREW MILLER
FRANCIS MCGRAW

70 AMSTELMOLEN

>LIST THE LENGTH, BEAM, DRAFT, MAXIMUM CRUISING SPEED AND
>DESTINATION OF EACH SHIP WITH MAYPORT OR NORFOLK AS HOME
>PORT.

	MAYPORT	CONSTELLATION	1072	130	36	35	NAPLES
75		KITTYHAWK	1072	130	36	35	NAPLES
		JOHN F. KENNEDY	1072	130	36	35	NORFOLK
		INDEPENDENCE	1039	130	37	33	3700N X 1700E
	NORFOLK	SARATOGA	1039	130	37	33	6000N X 3000W
		AMERICA	1072	130	36	35	UNKNOWN
80		STURGEON	292	32	26	30	ON X 4500E
		PHILADELPHIA	360	33	36	30	NORFOLK
		BATON ROUGE	360	33	36	30	NORFOLK
		LOS ANGELES	360	33	36	30	NORFOLK
		POGY	292	32	26	30	NORFOLK
85		GRAYLING	292	32	26	30	3500N X 1000E
		TAUTOG	292	32	26	30	3700S X 2000E
		WHALE	292	32	26	30	1500S X 1300E
		ASPRO	292	32	26	30	NORFOLK
		SUNFISH	292	32	26	30	NORFOLK
90		CHARLES F. ADAMS	437	47	20	33	NEW YORK
		HENRY B. WILSON	437	47	20	33	NEW YORK
		BARNEY	437	47	20	33	NEW YORK
		CLAUDE V. RICKETTS	437	47	20	33	NEW YORK
		LAWRENCE	437	47	20	33	NEW YORK
95		JOHN KING	437	47	20	33	NEW YORK
		HOEL	437	47	20	33	LIVERPOOL
		ROBISON	437	47	20	33	LIVERPOOL
		SELLERS	437	47	20	33	LIVERPOOL
		TOWERS	437	47	20	33	LIVERPOOL
100		LYNDE B. MCCORMICK	437	47	20	33	LIVERPOOL
		KAWISHIWI	582	68	42	25	NORFOLK
		HASSAYAMPA	582	68	42	25	NAPLES
		ASHTABULA	582	68	42	25	NAPLES

>LIST THE EMPLOYMENT, READINESS AND REASON FOR EACH SHIP
105 >WHICH IS NOT A SUBMARINE.

	AMERICA	OVERHAUL	C5
	KITTYHAWK	SURVEILLANCE OPERATIONS	C2
	STERETT	CARRIER ESCORT	C3
110	CHARLES F. ADAMS	CONVOY ESCORT	C3
	HOEL	CONVOY ESCORT	C2
115	CONNOLE	CONVOY ESCORT	C3
	RATHBURN	CONVOY ESCORT	C3
120	MEYERKORD	CONVOY ESCORT	C3

LIST THE HULL NUMBER, TYPE AND HOME PORT OF EACH

>SHIP IN TG26.4.

	KITTYHAWK	63	AIRCRAFT CARRIER	MAYPORT
125	BATON ROUGE	689	NUCLEAR POWERED ATTACK SUBMARINE	NORFOLK
	POGY	647	NUCLEAR POWERED ATTACK SUBMARINE	NORFOLK
	HOEL	13	GUIDED MISSILE DESTROYER	NORFOLK
	SELLERS	11	GUIDED MISSILE DESTROYER	NORFOLK
	GRAY	1054	FRIGATE	CHARLESTON

130>LIST THE COMMANDER AND COMMANDER'S LINEAL FOR EACH OF THEM.

	KITTYHAWK	CAPT R. SPRUANCE	4834
	BATON ROUGE	CDR V. QUIET	4839
	POGY	CDR J. HORNER	10104
	HOEL	CDR W. HUNT	10010
135	SELLERS	CDR C. PRESGROVE	10009
	GRAY	CDR P. LILLY	10014

>LIST THE QUANTITY OF CARGO AND CALL SIGN OF EACH SHIP WHOSE
>CARGO IS VANADIUM ORE OR CHROME ORE.

	CHROME ORE	JOHN TOULE	50T	UA1B
140		JACK J. PENDLETON	50T	UA1I
		JOSEPH E. MERRILL	50T	UA1H
		MERCHANT	150T	P3A2
		PIONEER	150T	P3A3
		VENTURE	150T	P3B0
145		VANGUARD	150T	P3A9
		VICTORY	150T	P3B1
	VANADIUM ORE	MORRIS E. CRAIN	23T	UA1E
		GREENVILLE VICTORY	50T	UA1A
		TRUMAN KIMLOW	50T	UA1F
150		SHIPPER	150T	P3A5
		SEAFARER	150T	P3A4

>LIST THE COMMANDER AND COMMANDER'S LINEAL FOR EACH SHIP WHICH

>DOES SURVEILLANCE OPERATIONS OR ANTI-SUBMARINE OPERATIONS.

	SURVEILLANCE OPERATIONS	CONSTELLATION	CAPT J. ELLISON	4832
155		KITTYHAWK	CAPT R. SPRUANCE	4834
		JOHN F. KENNEDY	CAPT P. MOFFETT	4833
		ASPRO	CDR T. CHANDLER	10105
		SUNFISH	CDR M. MORTON	10106
	ANTI-SUBMARINE OPERATIONS	PHILADELPHIA	CDR L. SNEAK	4840
160		BATON ROUGE	CDR V. QUIET	4839
		LOS ANGELES	CDR D. JONES	4838

>LIST THE DESTINATION, CALL SIGN, SPEED AND CARGO OF HIGH-INTEREST

>SHIPS WHICH DEPARTED RIGA AND WHOSE DESTINATION IS NOT SOME

>EUROPEAN PORT.

165 LUANDA K403 16 AIRCRAFT

H-2. MULTIPLE QUANTIFIERS

Obtaining output in tabular form can also be achieved through the use of quantifiers, especially if more than one is employed. Numerous examples have been included in other sections as well as Section H-1 in connection with LIST. Here just a few illustrations are given of possible combinations of quantifiers.

Line 1 contains HOW MANY and EACH OF, line 10 the same quantifiers plus a relative clause.

Line 16 illustrates HOW MANY OF with a relative clause containing the conjunction OR of four noun items.

In line 22 HOW MANY is followed by a relative clause containing the AT LEAST quantifier.

Line 34 illustrates the use of two EACH OF quantifiers, the second one being in a relative clause.

In line 50 the quantifier WHICH OF appears together with the EACH quantifier.

```

HOW MANY SHIPS ARE OWNED BY EACH OF THE EUROPEAN COUNTRIES?
FRANCE ..... 0
SPAIN ..... 0
ITALY ..... 0
5 NORWAY ..... 19
WEST GERMANY ..... 8
NETHERLANDS ..... 10
UNITED KINGDOM ..... 31
PORTUGAL ..... 0
10 >HOW MANY SHIPS ARE OWNED BY EACH OF THE EUROPEAN COUNTRIES?
    >WHICH OWNS SHIPS?
        NORWAY ..... 19
        WEST GERMANY ..... 8
        NETHERLANDS ..... 10
15 UNITED KINGDOM ..... 31
    >HOW MANY OF THE SHIPS WHICH SAIL FOR LIVERPOOL CARRY
    >WHEAT, COAL, OIL OR FARM MACHINERY?
        FARM MACHINERY ..... 3
        COAL ..... 4
20 WHEAT ..... 6
    OIL ..... 18

```

HOW MANY SHIPS APPROACH EACH PORT WHICH IS THE DESTINATION?
 >OF AT LEAST TWO SHIPS?

NORFOLK 8
 25 NAPLES 5
 OSLO 4
 MONROVIA 2
 NEW YORK 28
 ALEXANDRIA 3
 30 LUANDA 2
 LISBON 3
 LIVERPOOL 54
 WILMINGTON 27

>WHAT IS THE CALL SIGN, LONGITUDE AND LATITUDE OF EACH?

35 >OF THE SUBMARINES THAT BELONG TO EACH OF THE COUNTRIES?

UNITED STATES	PHILADELPHIA	NABK	2000	-3700
	BATON ROUGE	NABJ	4130	-1500
	LOS ANGELES	NABI	4500	0
	POGY	NABP	1000	3500
40	ASPRO	NABQ	-3000	3000
	SUNFISH	NABR	-6000	3000
SOVIET UNION	USSR 10	RN17	-2710	2310
	USSR 15	RN22	-5300	1615
	USSR 14	RN21	-4305	1630
13	USSR 13	RN20	-3815	1940
	USSR 12	RN19	-3410	1945
	USSR 11	RN18	-3100	2150
	USSR 16	RN23	5410	900
	USSR 17	RN24	-3005	6000

50 >WHICH OF THE MERCHANT VESSELS THAT BELONG TO NORWAY
 >HAVE EACH EUROPEAN PORT AS DESTINATION?

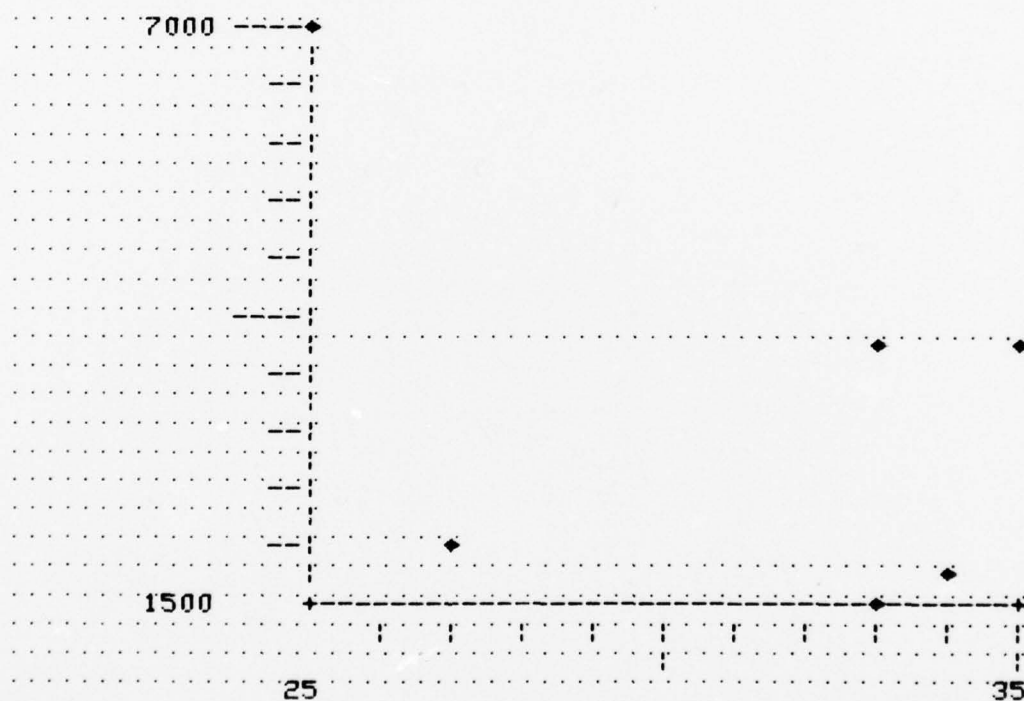
LEHAVRE TAMESIS
 NAPLES TANCREO
 OSLO TAIPING
 55 TAGRIS
 TAGAYTRAY
 TABOR
 ROTTERDAM TAMPA
 LONDON TALLEYRAND
 60 LISBON TENNESSEE
 TENERIFFA
 TENNERAIRE

H-3. GRAPHIC DISPLAY OF DATA

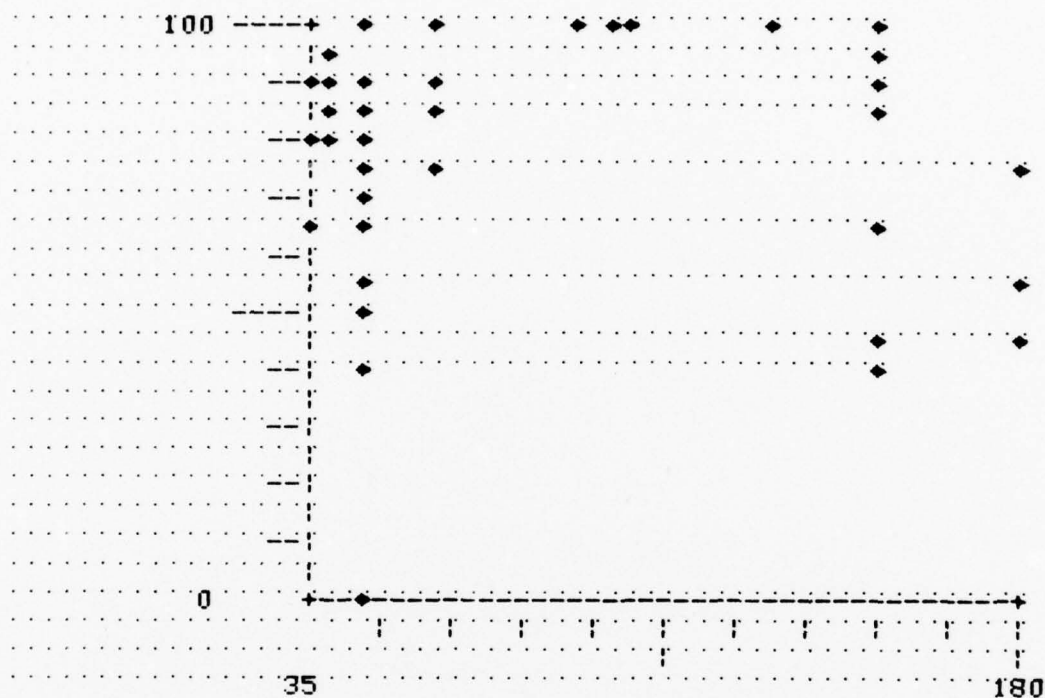
Two ways are available for graphic display of the data:
plotting and histogramming.

Scatter plots can be obtained with commands such as these:

>PLOT MAXIMUM CRUISING RANGE AGAINST MAXIMUM
>CRUISING SPEED OF US NAVAL SHIPS.

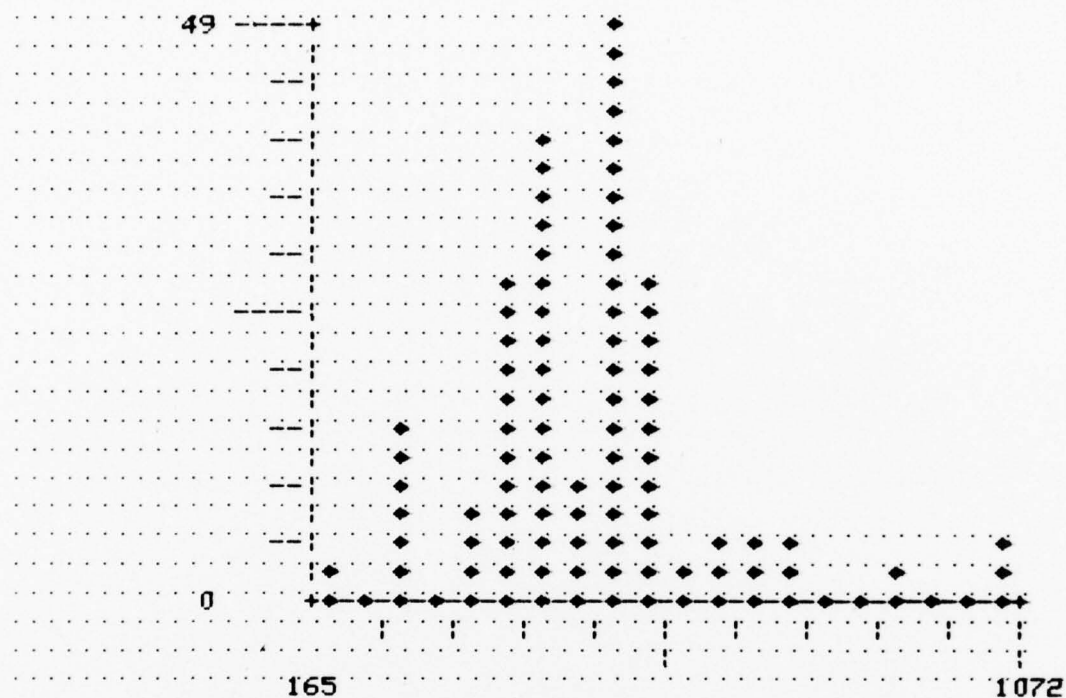


>PLOT PERCENT FUEL AGAINST ENDURANCE OF SHIPS.

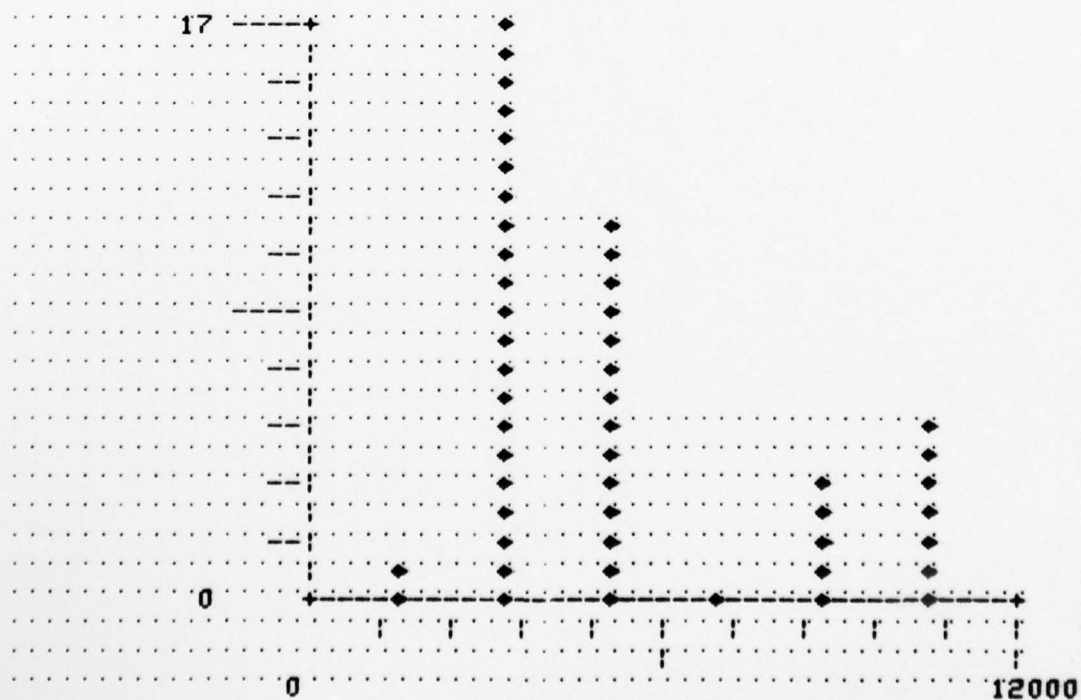


Histograms may be used in order to see the distribution of the values of some attributes of objects. The commands for obtaining them are such as those illustrated on the following page.

>HISTOGRAM LENGTHS OF SHIPS.



>HISTOGRAM PERCENT FUEL TIMES NORMAL CRUISING RANGE
>DIVIDED BY 100 OF US NAVAL SHIPS.



III. MODIFYING AND EXTENDING THE LANGUAGE AND THE DATA BASE

Perhaps the most important feature of REL is its extensibility, the facility offered the typical end-user unskilled in programming to modify his data base and language by changing the existing data base, adding new data items (and thus vocabulary), and defining new expressions and concepts, including such complex ones as verbs. Each of these will be discussed and illustrated here, except for verbs which were discussed in Section II-E.

The facilities allow the user to change his data and language to update it according to the changing situation, which in many real applications happens all the time. They also allow him to explore his data along a variety of paths, including the formation and testing of hypotheses.

A. MODIFYING AN EXISTING DATA BASE

A-1. CHANGING AN EXISTING DATA BASE

As information about existing data base items changes, changes can be made in the data base to reflect the new information. For instance, if a change has occurred in the commanding officer of a given ship, say, the KITTYHAWK, from CAPT R. SPRUANCE to CAPT P. MOFFETT at a certain time, the data base can be changed by statements such as those found in the protocol below in lines 11-17.

In general, changes can be made by deleting the existing information, as in line 3 through a negative statement, and entering the new information, as in line 5.

If it is desirable to include information about times when changes took place, this can be done as in lines 14 and 17.

Changes can be made concerning single entities, as in line 27, or about conjoined entities, as in line 29, or about a class, as in line 31.

```

>WHAT IS THE PERCENT FUEL OF THE BIDDLE?
88
>THE PERCENT FUEL OF THE BIDDLE IS NOT 88.
DATA HAS BEEN DELETED.
5 >THE PERCENT FUEL OF THE BIDDLE IS 72.
DATA HAS BEEN ADDED.
>WHAT IS BIDDLE'S PERCENT FUEL?
72
>WHO COMMANDS THE KITTYHAWK?
10 >CAPT R. SPRUANCE
>CAPT R. SPRUANCE IS NOT THE COMMANDING OFFICER OF
>THE KITTYHAWK.
DATA HAS BEEN DELETED.
>THE COMMANDER OF THE KITTYHAWK WAS CAPT
15 >R. SPRUANCE ENDING JUNE 4, 1976.
DATA HAS BEEN ADDED.
>CAPT P. MOFFETT WAS COMMANDING OFFICER OF THE
>KITTYHAWK STARTING JUNE 5, 1976.
DATA HAS BEEN ADDED.
20 >WHO COMMANDED THE KITTYHAWK?
CAPT R. SPRUANCE ENDING JUNE 04, 1976
CAPT P. MOFFETT STARTING JUNE 05, 1976
>WHAT IS THE SPEED OF EACH TU25.3.2 SHIP?
KITTYHAWK 20
25 BATON ROUGE 0
KNOX 0
>THE SPEED OF THE KITTYHAWK IS NOT 20.
DATA HAS BEEN DELETED.
>THE SPEED OF THE BATON ROUGE AND KNOX IS NOT 0.
30 DATA HAS BEEN DELETED.
>THE SPEED OF TU25.3.2 SHIPS IS 10.
DATA HAS BEEN ADDED.
>WHAT IS THE SPEED OF EACH TU25.3.2 SHIP?
KITTYHAWK 10
35 BATON ROUGE 10
KNOX 10

```

Some more complex examples are provided in the next protocol.

The statement in line 8 deletes the existing information about LOS ANGELES CLASS SHIPS, which are known to be PHILADELPHIA, BATON ROUGE, and LOS ANGELES of lines 2, 3, and 4 respectively. The statement in line 10 assigns a speed to these ships collectively, and the change is reflected in the answer to line 12. The speed of POGY in line 16 remains unchanged.

Changes can be made about an individual and a class in a single statement, as can be seen from line 19. Since no data is deleted, this statement simply adds the new data to the existing information, as can be seen from the answer to the question in line 22.

In lines 33 and 35 part of the information is again deleted, resulting in the change revealed in the answer to the question in line 37.

This protocol illustrates how a succession of changes can be made in a dynamically changing environment.

```

WHAT IS THE SPEED OF EACH US SUBMARINE?
PHILADELPHIA UNKNOWN
BATON ROUGE UNKNOWN
LOS ANGELES UNKNOWN
5 POGY UNKNOWN
ASPRO 8
SUNFISH 8
>THE SPEED OF EACH LOS ANGELES CLASS SHIP IS NOT UNKNOWN.
DATA HAS BEEN DELETED.
10 >THE SPEED OF EACH LOS ANGELES CLASS SHIP IS 10.
DATA HAS BEEN ADDED.
>WHAT IS THE SPEED OF EACH US SUBMARINE?
PHILADELPHIA 10
BATON ROUGE 10
15 LOS ANGELES 10
POGY UNKNOWN
ASPRO 8
SUNFISH 8
>THE SPEED OF THE ASPRO AND EACH LOS ANGELES CLASS SHIP
20 >IS 9.
DATA HAS BEEN ADDED.

```


WHAT IS THE HULL NUMBER AND SPEED OF EACH US SUBMARINE?
 PHILADELPHIA 690 9
 690 10
 25 BATON ROUGE 689 9
 689 10
 LOS ANGELES 688 9
 688 10
 POGY 647 UNKNOWN
 30 ASPRO 648 8
 648 9
 SUNFISH 649 8
 THE SPEED OF THE ASPRO IS NOT 8.
 DATA HAS BEEN DELETED.
 35 THE SPEED OF EACH LOS ANGELES CLASS SHIP IS NOT 10.
 DATA HAS BEEN DELETED.
 WHAT IS THE HULL NUMBER AND SPEED OF EACH US SUBMARINE?
 PHILADELPHIA 690 9
 BATON ROUGE 689 9
 40 LOS ANGELES 688 9
 POGY 647 UNKNOWN
 ASPRO 648 9
 SUNFISH 649 8

The next protocol illustrates how a change can be made about one entity without disturbing others which share the same characteristics. In this case, we have three destinations of SHIPS THAT CARRY GENERAL FOODS, and we would like to change OSLO (line 4) to LISBON. The desired effect would not be achieved by statements such as OSLO IS NOT THE DESTINATION OF SHIPS THAT CARRY GENERAL FOODS and LISBON IS THE DESTINATION OF SHIPS THAT CARRY GENERAL FOODS. The result of such statements would be that OSLO would no longer be a destination, but LISBON would be added as a destination of all ships THAT CARRY GENERAL FOODS, thus also those whose destination is NAPLES and MONROVIA, which is not what is intended here since we want to only substitute LISBON for OSLO. The protocol illustrates how this can be done.

In line 6, LISBON is made a DESTINATION but only of those SHIPS WHOSE DESTINATION IS OSLO AND THAT CARRY GENERAL FOODS. The use of two conjoined relative clauses is shown to single out that particular group of ships. The result of this change is shown in the answer to

the question in line 9. As can be seen, LISBON is added as a destination of ships whose destination was only OSLO.

To remove OSLO, the negative statement in line 21 is used, and the desired change is obtained, as shown by the answer to the question in line 24.

```

>WHAT ARE THE DESTINATIONS OF SHIPS THAT
>CARRY GENERAL FOODS?
  NAPLES
  OSLO
5  MONROVIA
>LISBON IS A DESTINATION OF SHIPS WHOSE DESTINATION
>IS OSLO AND THAT CARRY GENERAL FOODS.
  DATA HAS BEEN ADDED.
>WHAT IS THE DESTINATION OF EACH SHIP WHOSE
10 >CARGO IS GENERAL FOODS?
  TALABOT   MONROVIA
  TAIPING   OSLO
           LISBON
  TAGRIS    OSLO
15          LISBON
  TAGAYTRAY OSLO
           LISBON
  TABOR     OSLO
           LISBON
20  TANCRED   NAPLES
>OSLO IS NOT THE DESTINATION OF SHIPS THAT
>CARRY GENERAL FOODS.
  DATA HAS BEEN DELETED.
>WHAT IS THE DESTINATION OF EACH SHIP WITH
25 >GENERAL FOODS AS CARGO?
  TALABOT   MONROVIA
  TAIPING   LISBON
  TAGRIS    LISBON
  TAGAYTRAY LISBON
30  TABOR     LISBON
  TANCRED   NAPLES

```

A-2. ADDING A NEW PIECE OF INFORMATION TO AN EXISTING DATA BASE

A new piece of information may have been acquired, say, about the employment of some ships. This information can be added either about each of these ships individually, or collectively, as can be seen from the protocol below.

WHAT IS THE EMPLOYMENT OF EACH YANKEE CLASS SHIP?

NONE

>WHAT ARE YANKEE CLASS SHIPS?

USSR 5

USSR 4

USSR 3

THE EMPLOYMENT OF USSR 5 IS ANTI-SUBMARINE OPERATIONS.

DATA HAS BEEN ADDED.

THE EMPLOYMENT OF YANKEE CLASS SHIPS IS ANTI-SUBMARINE
>OPERATIONS.

DATA HAS BEEN ADDED.

WHAT IS THE SPEED AND EMPLOYMENT OF EACH YANKEE CLASS SHIP?

USSR 5 3 ANTI-SUBMARINE OPERATIONS

USSR 4 3 ANTI-SUBMARINE OPERATIONS

USSR 3 3 ANTI-SUBMARINE OPERATIONS

B. ADDING DATA ITEMS

One can very well imagine a situation in which information would somehow be obtained about another U.S. Navy ship which had been dispatched from Norfolk to join those currently in the Mediterranean port Naples. Whatever items of information had been obtained about ships can immediately be incorporated in the user's data base and be available for immediate use.

There are the following ways of introducing new primitive data, that is data which is not defined in terms of existing data (see discussion on page 93).

B-1. INTRODUCING NEW INDIVIDUALS

- (a) XXX:=NAME
e.g. ALBATROS:=NAME
- (b) XXX:=NAME(ANIMATE)
e.g. CAPT T. FERN:=NAME(ANIMATE)

B-2. INTRODUCING NEW CLASSES

- (a) XXX:=CLASS
e.g. RADIATION HAZARD SHIP:=CLASS
- (b) XXX:=CLASS(ANIMATE)
e.g. SPECIAL OFFICER:=CLASS(ANIMATE)

B-3. INTRODUCING NEW RELATIONS

- (a) XXX:=RELATION
e.g. COMPUTER:=RELATION
- (b) XXX:=RELATION(ANIMATE)
e.g. RADIATION OFFICER:=RELATION(ANIMATE)

B-4. INTRODUCING NEW NUMBER RELATIONS

- XXX:=NUMBER RELATION
e.g. RADIATION LEVEL:=NUMBER RELATION

Note: The notation XXX is used to indicate any character or character combination, for example JOHN or INCOME. Thus XXX:=NAME stands for a case such as ALBATROS:=NAME. Spaces in the format before and after ":" and "=" are ignored.

AD-A059 927 CALIFORNIA INST OF TECH PASADENA
REL ENGLISH FOR THE USER, (U)
AUG 78 B H DOSTERT, F B THOMPSON

CALIFORNIA INST OF TECH PASADENA
REL ENGLISH FOR THE USER, (U)
AUG 78 B H DOSTERT, F B THOMPSON

F/G 9/2

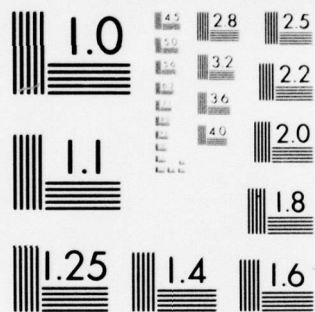
N00039-76-C-0374

NL

UNCLASSIFIED

2 OF 2
AD
A059927

END
DATE
FILMED
12-78
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

B-5. DISCUSSION OF THE WAYS OF INTRODUCING NEW DATA

a. The Ways of Introducing New Individuals

XXX:=NAME

We can introduce a new ship, say, the ALBATROS, by saying:

>ALBATROS:=NAME
'DEFINED.'

Now, whatever data we have about it can be introduced through statements such as:

>THE ALBATROS IS A LOS ANGELES CLASS SHIP.
'DATA HAS BEEN ADDED.'
>THE HULL NUMBER OF THE ALBATROS IS 225.
'DATA HAS BEEN ADDED.'
>THE DESTINATION OF THE ALBATROS IS NORFOLK.
'DATA HAS BEEN ADDED.'
>THE PERCENT FUEL OF THE ALBATROS IS 85.
'DATA HAS BEEN ADDED.'

and so on, provided that all the vocabulary is known to the system. If we came, for instance, to the name of the commanding officer of the ALBATROS and that name is not in the data base, it is necessary to introduce it. Thus,

XXX:=NAME(ANIMATE)

>CAPT T. FERN:=NAME(ANIMATE)
'DEFINED.'

Note: The distinction between NAME and NAME(ANIMATE) just as between CLASS and CLASS(ANIMATE) and RELATION and RELATION(ANIMATE) discussed below should always be made when relevant. The distinction is more grammatical than following the facts of the real world, that is ANIMATE items are those to whom we want to refer to with such pronouns as HE, SHE, HIS. Thus, if we wanted to talk of ships as SHE we would have to make them animate; but if we do not want to refer to a male dog as HE and are satisfied with using IT instead we need not make Fido animate. All humans should be introduced as animate.

Data can then be added about CAPT T. FERN, as in line 1 below. It will be noticed from the answer to the command in line 3 that ALBATROS has been added to the LOS ANGELES CLASS SHIPS, and that the data about its hull number and destination, as well as commander, has been added.

```
>THE COMMANDING OFFICER OF THE ALBATROS IS CAPT T. FERN.
DATA HAS BEEN ADDED.
>LIST THE COMMANDER, HULL NUMBER AND DESTINATION OF
EACH LOS ANGELES CLASS SHIP.
PHILADELPHIA CDR L. SNEAK 690 NORFOLK
BATON ROUGE CDR V. QUIET 689 NORFOLK
LOS ANGELES CDR D. JONES 688 NORFOLK
ALBATROS CAPT T. FERN 225 NORFOLK
```

b. The Ways of Introducing New Classes

XXX:=CLASS

If for some reason we wish to single out a group of items, for example ships that have been exposed to high radiation, we can designate these, for instance, as RADIATION HAZARD SHIPS in the following way:

```
>RADIATION HAZARD SHIP:=CLASS
DEFINED.
```

and assign the given ships to this new class, for example:

```
SHIPS THAT WERE IN TU24.2.2 FROM MARCH 16, 1976
>TO JUNE 20, 1976 ARE RADIATION HAZARD SHIPS.
DATA HAS BEEN ADDED.
>WHAT ARE RADIATION HAZARD SHIPS?
HOEL
ROBISON
SELLERS
TOWERS
LYNDE B. MCCORMICK
KNOX
```

XXX:=CLASS(ANIMATE)

If a group of humans needs to be singled out for some purpose, for example officers who have been selected for some special award or study, we can designate them, for instance, as SPECIAL OFFICERS:

>SPECIAL OFFICER:=CLASS(ANIMATE)
'DEFINED.'

and assign to it officers in question as illustrated in the protocol below.

>CAPT S. JACKSON IS A SPECIAL OFFICER.
'DATA HAS BEEN ADDED.'
>ALL COMMANDING OFFICERS WHO COMMAND LOS ANGELES CLASS
>SHIPS ARE SPECIAL OFFICERS.
'DATA HAS BEEN ADDED.'
>WHO ARE SPECIAL OFFICERS?
'CDR L. SNEAK
'CDR V. QUIET
'CDR D. JONES
'CAPT S. JACKSON
'CAPT T. FERN

c. The Ways of Introducing New Relations

XXX:=RELATION

New relations can also be introduced as primitive relations.

If we want to add to the data on some ships information about, for instance, their computer capability, where the various computers are Y42, Y43, and Y44, this can be done as follows.

The names of the computers have to be introduced, unless they are already known to the system; thus,

>Y42:=NAME
'DEFINED.'
>Y43:=NAME
'DEFINED.'
>Y44:=NAME
'DEFINED.'

COMPUTER is introduced as a relation (the order of these two operations can obviously be reversed).

```
>COMPUTER:=RELATION
  DEFINED.
```

Now we can establish the relationship between a given computer and a given ship as in lines 1, 3, and 5. It will be noticed that the information in line 5 is added about a class of data. Questions such as in line 7 and 9 show that the new data has been added.

```
>THE COMPUTER OF THE LOS ANGELES IS Z42.
  DATA HAS BEEN ADDED.
>THE COMPUTER OF KITTYHAWK CLASS SHIPS IS Z43.
  DATA HAS BEEN ADDED.
5 >THE COMPUTER OF US SUBMARINES IS Z44.
  DATA HAS BEEN ADDED.
  >WHAT COMPUTER DOES THE AMERICA HAVE?
    * Z43
  >HOW MANY SHIPS HAVE EACH COMPUTER?
10 Z44 11
   Z43 4
   Z42 1
```

```
XXX:=RELATION(ANIMATE)
```

We can introduce for a ship such a new relation involving animate objects as

```
>RADIATION OFFICER:=RELATION(ANIMATE)
  DEFINED.
```

and if the commanding officer of a ship wants to designate a person to be a radiation officer, he will proceed as shown in the protocol. First, he will name the officer, possibly add some data about him, and establish him as the radiation officer. This will allow a question such is illustrated in the protocol.


```

>LT 'B. PIKE:=NAME(ANIMATE)
  DEFINED.
>LT 'B. PIKE IS THE RADIATION OFFICER OF THE ALBATROS.'
  DATA HAS BEEN ADDED.
>LT 'B. PIKE'S LINEAL IS 1307.'
  DATA HAS BEEN ADDED.
>WHAT IS THE LINEAL OF THE RADIATION OFFICER OF THE ALBATROS?
  1307

```

d. The Ways of Introducing New Number Relations

XXX:=NUMBER RELATION

The number relation serves to introduce a new numerical data item, for example:

```

>RADIATION INDEX:=NUMBER RELATION
  DEFINED.

```

This allows adding of information and asking questions as in the protocol below.

```

>THE RADIATION INDEX OF THE AMERICA IS 56.
  DATA HAS BEEN ADDED.
>THE RADIATION INDEX OF THE KNOX, THE SELLERS AND
>THE BIDDLE IS 63.
5 DATA HAS BEEN ADDED.
>THE RADIATION INDEX OF FORRESTAL CLASS SHIPS IS 40.
  DATA HAS BEEN ADDED.
>WHICH SHIPS HAVE A RADIATION INDEX GREATER THAN 50?
  AMERICA
10 BIDDLE
  SELLERS
  KNOX

```

It will be noticed that in line 3 the data is added about three ships at once conjoined through AND, and in line 6 about a whole class of ships.

C. DEFINITIONS

An existing data base can be significantly extended by the user through definitions of new concepts and expressions. This capability allows the user to introduce terms and concepts by defining them on the basis of existing ones in such a way that their meaning is most natural and appropriate for the user.

C-1. SIMPLE DEFINITIONS

A number of simple definitions may prove quite useful and helpful in ongoing work. Such are, for instance, abbreviations. The ship named JOHN F. KENNEDY may be conveniently referred to as JFK. To be able to do so we define the latter in terms of the former as follows:

```
>DEF:JFK:JOHN F. KENNEDY
  DEFINED.
```

If abbreviations or special spellings of any kind are introduced, one has to be consistent in using the form that was introduced, or else have several definitions, for example:

```
>DEF:JFK:JOHN F. KENNEDY
  DEFINED.
>DEF:J.F.K.:JOHN F. KENNEDY
  DEFINED.
```

Other simple definitions may be different terms which are used interchangeably.

In the following examples the term HOME PORT is the one that is already known to the system (as a primitive relation), and the others are defined on the basis of it.

Note: Terms and concepts introduced through definition on the basis of existing ones are preceded by DEF:, unlike the primitive ones discussed earlier (see page 87), and the format does not include "=". Spaces before and after ":" are ignored.

- (a) >DEF:HOME STATION:HOME PORT
DEFINED.
- (b) >DEF:HOME CITY:HOME PORT
DEFINED.
- (c) >DEF: ASSIGNED HOME PORT:HOME PORT
DEFINED.

Once a term becomes known through a definition, as, for instance, HOME STATION through (a), a new expression such as in (d) can be introduced in terms of it, as follows:

- (d) >DEF:PERMANENT STATION:HOME STATION
DEFINED.

If, however, such a series of definitions becomes very long it may be more costly in time than defining on the basis of primitively existing terms (i.e. HOME PORT in this case).

For other examples of simple paraphrasing definitions see the following protocol.

```
>DEF:DEPARTURE POSITION:DEPARTURE POINT
  DEFINED.
>DEF:CARGO:CARGO TYPE
  DEFINED.
>DEF:ECONOMICAL CRUISING RANGE:NORMAL CRUISING RANGE
  DEFINED.
>DEF:CURRENT EMPLOYMENT:EMPLOYMENT
  DEFINED.
>DEF:CURRENT ASSIGNMENT:EMPLOYMENT
  DEFINED.
>DEF:STATE OF READINESS:COMBAT READINESS RATING
  DEFINED.
>DEF:INOPERATIVE SONAR:SONAR FAILURE
  DEFINED.
```

C-2. COMPLEX DEFINITIONS

Complex definitions may involve subordinate clauses, extensive calculations, the use of variables, the use of ambiguity, defining relations.

The user's needs and imagination may lead to the definition of quite complex concepts through lengthy definitions which then can be used in rather simple sentences just like simple primitive concepts.

a. With Subordinate Clauses

```
>DEF:NOREGIAN SHIP:SHIP WHOSE FLAG IS NORWAY
  DEFINED.
>DEF:OIL CARRYING VESSEL:SHIP WHOSE CARGO IS OIL
  DEFINED.
>DEF:SUPERSHIP:SHIP WITH LENGTH GREATER THAN 700
  DEFINED.
```

Suppose that we want to define the concept of EFFECTIVE RANGE for U.S. ships which will have the meaning of "how far a given ship can go at its maximum speed with the amount of fuel that it currently has." This would not be a meaningful notion for submarines, as they appear in the data base, since their fuel percent is always 100. Therefore, we first want to limit the group of ships under consideration to all but the submarines. We can define them as follows, using a subordinate clause:

```
>DEF:SURFACE SHIP:SHIP WHICH IS NOT A SUBMARINE
  DEFINED.
```

b. With Extensive Calculations

The concept which we want to define, namely EFFECTIVE RANGE, involves knowing

- (1) What a given ship's maximum speed is.
- (2) What its fuel percent is.
- (3) How much fuel it uses at its maximum speed.

Since maximum speed is given in the data base in terms of hours and fuel consumption in terms of days, we may want to introduce the term MAXIMUM FUEL CONSUMPTION, abbreviated to M FUELC, as follows:

```
>DEF:M FUELC:26/24
  DEFINED.
```

which gives us maximum fuel consumption per hour (26 percent is fuel consumption of U.S. Navy ships in 24 hours in this data base). The concept EFFECTIVE RANGE can be defined now in terms of PERCENT FUEL, MAXIMUM CRUISING SPEED, and M FUELC as follows:

```
>DEF:EFFECTIVE RANGE:(PERCENT FUEL/100)♦(MAXIMUM
>CRUISING RANGE/ M FUELC
  DEFINED.
```

If we do not introduce the term M FUELC the definition may alternately be stated in either of these ways:

```
>DEF:EFFECTIVE RANGE:(PERCENT FUEL/100)♦(MAXIMUM
>CRUISING RANGE/(26/24))
  DEFINED.
>DEF:EFFECTIVE RANGE:(PERCENT FUEL ♦ MAXIMUM
>CRUISING RANGE ♦ 24)/(26♦100)
  DEFINED.
```

Once we have the concept EFFECTIVE RANGE we can use it in questions the same way as we would use a primitive notion. The protocol that follows illustrates this.

Note: The use of parentheses is necessary to indicate precedence, as in ordinary arithmetical operations.

>WHAT IS THE EFFECTIVE RANGE OF THE KITTYHAWK?

3249.23

>WHAT IS THE EFFECTIVE RANGE OF SHIPS WHOSE ENDURANCE
>IS GREATER THAN 100?

UNKNOWN

UNKNOWN

UNKNOWN

4873.84

8529.23

5981.54

1735.39

1606.15

812.308

1200

1643.08

16449.2

11132.3

6646.15

14953.8

>WHAT IS THE ENDURANCE OF SHIPS WHOSE
>EFFECTIVE RANGE IS GREATER THAN 4000?

60

60

60

180

180

180

150

150

150

150

>WHAT IS THE EFFECTIVE RANGE OF EACH AIRCRAFT CARRIER
>WITH EACH FLAG?

UNITED STATES CONSTITUTION 3692.31

SARATOGA 3692.31

AMERICA 0

KITTYHAWK 3249.23

JOHN F. KENNEDY 3323.08

INDEPENDENCE 3692.31

SOVIET UNION LENINGRAD 2547.69

MOSKVA 2436.92

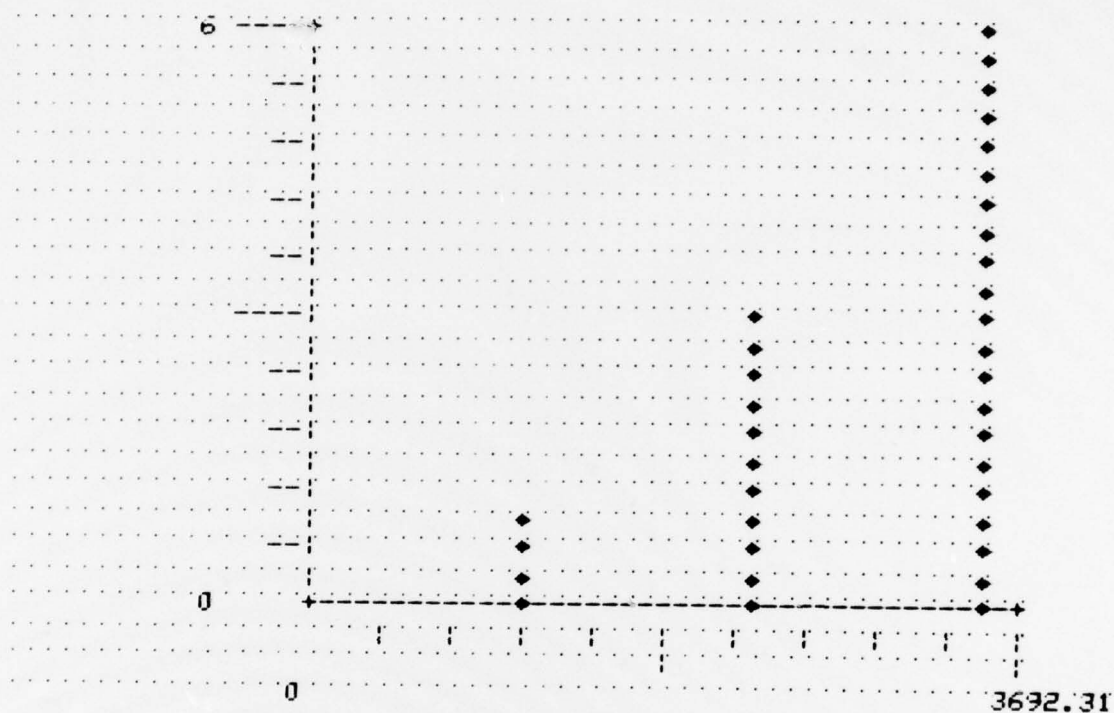
KIEV 2436.92

MINSK 2298.46

>WHAT IS THE MAXIMUM AND MINIMUM EFFECTIVE RANGE OF
>AIRCRAFT CARRIERS?

3692.31 0

HISTOGRAM EFFECTIVE RANGE OF AIRCRAFT CARRIERS.



c. With Variables

Definitions can employ variables, which constitute a powerful mechanism for allowing a generalized statement. The variables, which are expressed between double quotation marks (" "), have no values. They stand for 'things like what is between " ".'

- (1) If a number is between " ", any number can be used in its place.
- (2) If nouns like SHIP, SPECIAL OFFICER, CAPT R. SPRUANCE, LENGTH are between " ", any noun or noun phrase can be used.

The protocol that follows illustrates the use of definitions with variables.

The question which appears under each definition illustrates how the defined terms can be used.

```

>DEF:F("8","9"):"8"♦"9"♦"9"♦"9"
  "DEFINED."
>WHAT IS F(3,4)?
  25
>WHAT IS F(COS(30),F(5,.07))?
  625.999
>DEF:"2"K SHIP:SHIP WHOSE MAXIMUM CRUISING RANGE IS<
>GREATER THAN "2"♦1000
  "DEFINED."
>WHAT ARE THE FLAGS OF 25K SHIPS?
  UNITED STATES
  LIBERIA
  UNITED KINGDOM
>DEF:"NORFOLK" STATIONED "SHIP": "SHIP" WHOSE HOME PORT<
>IS "NORFOLK"
  "DEFINED."
>LIST THE NAME, HULL NUMBER AND COMMANDER OF THE CHARLESTON<
>STATIONED FRIGATES.
  KNOX *****1052 "CDR C. JACKSON
  CONNOLLY *****1056 "CDR W. CARL
  HEBURN *****1055 "CDR D. WEISGERBER
  GRAY *****1054 "CDR P. LILLY
  ROARK *****1053 "CDR J. ELLIOTT
  RATHBURN *****1057 "CDR W. MORAN
  LANG *****1060 "CDR D. LEACH
  W. S. SIMS *****1059 "CDR D. RODGERS
  MEYERKORD *****1058 "CDR P. RILEY
>DEF:"US" FLAG "SHIP": "SHIP" WHOSE FLAG IS "US"
  "DEFINED."
>HOW MANY LIBERIAN FLAG TANKERS ARE THERE?
  5

```

The example below shows that a given variable can appear in more than one place on the right-hand side.

```

>DEF:LONGEST "SHIP": "SHIP" WHOSE LENGTH IS THE MAXIMUM<
>LENGTH OF "SHIP"s
  "DEFINED."
>WHAT IS THE NAME AND LENGTH OF THE LONGEST SUBMARINE?
  PHILADELPHIA "360
  BATON ROUGE "360
  LOS ANGELES "360

```

d. With Ambiguity

It may be at times useful to define a concept in ambiguous ways. If for some reason we want to compare certain qualities of ships, for instance, we can define ships with these qualities under a common name. Thus,

```
>DEF:'SUPERSHIP':SHIP 'WHOSE 'LENGTH 'IS 'GREATER 'THAN '900
  'DEFINED.'
>DEF:'SUPERSHIP':SHIP 'WHOSE 'ENDURANCE 'IS 'GREATER 'THAN '160
  'DEFINED.'
```

Answers to questions about items defined in more than one way reflect this ambiguity, as in the examples below:

```
>WHAT 'ARE 'SUPERSHIPS?
'AMBIGUOUS:'
'#1
'KRENOMETR
'BAROGRAPH
'AMPERMETR
'#2
'CONSTELLATION
'SARATOGA
'AMERICA
'KITTYHAWK
'JOHN 'F.' 'KENNEDY
'INDEPENDENCE
'KIEV
'MINSK
>WHAT 'IS 'THE 'LENGTH 'AND 'ENDURANCE 'OF 'EACH 'SUPERSHIP?
'AMBIGUOUS:'
'#1
'CONSTELLATION ' ' '1072 ' '49
'SARATOGA ' ' '1039 ' '49
'AMERICA ' ' '1072 ' '49
'KITTYHAWK ' ' '1072 ' '49
'JOHN 'F.' 'KENNEDY ' '1072 ' '49
'INDEPENDENCE ' ' '1039 ' '49
'KIEV ' ' '925 ' '60
'MINSK ' ' '925 ' '60
'#2
'KRENOMETR ' '165 ' '180
'BAROGRAPH ' '165 ' '180
'AMPERMETR ' '165 ' '180
```

e. Defining Relations

(1) As Converse:

In defining relations it is sometimes convenient to use the notion of the converse of a relation. Examples of this notion are CHILD as converse of PARENT, SUBORDINATE OFFICER as converse of SUPERIOR OFFICER. The converse of a given relation can be defined as:

DEF:XXX:CONVERSE OF YYY

The relation whose converse is to be defined obviously has to be known to the system. The following sequence gives an example of a converse definition and its use.

```
DEF:COMMAND:CONVERSE OF COMMANDER
  DEFINED.
>WHO IS THE COMMANDER OF THE ROARK?
  CDR J. ELLIOTT
>WHAT IS THE COMMAND OF CDR J. ELLIOTT?
  ROARK
DEF:HOME:HOME PORT OF COMMAND
  DEFINED.
>WHAT IS THE HOME PORT AND COMMANDER OF THE KITTYHAWK?
  MAYPORT  CAPT R. SPRUANCE
>WHAT IS CAPT R. SPRUANCE'S HOME?
  MAYPORT
```

(2) Through Existing Relations:

New relations may be defined in terms of existing relations, as in the example below, and the example of EFFECTIVE RANGE in the section on definitions with extensive calculations.

```
>DEF:EFFECTIVE ENDURANCE:ENDURANCE * PERCENT FUEL / 100
  DEFINED.
>WHAT IS THE EFFECTIVE ENDURANCE OF EACH AIRCRAFT\
>CARRIER WITH EACH FLAG?
  UNITED STATES  CONSTELLATION      45
                  SARATOGA          45
                  AMERICA            0
                  KITTYHAWK         39.6
                  JOHN F. KENNEDY    40.5
                  INDEPENDENCE       45
  SOVIET UNION   LENINGRAD          55.2
                  MOSKVA            52.8
                  KIEV              52.8
                  MINSK              49.8
```


A new relation can also be defined in terms of a relation that is itself defined. The sequence below shows the definition of FATHER as MALE PARENT, the converse definition of CHILD, and the definition of GRANDFATHER in terms of FATHER. (No use of these terms is shown here, since none of the data bases used for these protocols includes data on family relationships.)

```
PARENT:=RELATION(ANIMATE)
DEFINED.
>MALE:=CLASS
DEFINED.
>DEF:FATHER:MALE PARENT
DEFINED.
>DEF:CHILD:CONVERSE OF PARENT
DEFINED.
>DEF:GRANDFATHER:FATHER OF FATHER
DEFINED.
```

C-3. MANAGING DEFINITIONS

a. Inquiring about Definitions

The most general question is the one exemplified below,

WHAT ARE DEFINITIONS?

which can also be asked in these ways:

WHAT ARE THE DEFINITIONS?

WHAT HAS BEEN DEFINED?

WHAT DEFINITIONS ARE THERE?

WHAT ARE DEFINITIONS?
 THERE ARE 34 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
 RESPOND WITH "ALL", "NONE", OR A NUMBER.
 /10

US:UNITED STATES
 AMERICAN:UNITED STATES
 USSR:SOVIET UNION
 RUSSIA:SOVIET UNION
 RUSSIAN:SOVIET UNION
 SOVIET:SOVIET UNION
 UK:UNITED KINGDOM
 ENGLAND:UNITED KINGDOM
 ENGLISH:UNITED KINGDOM
 BRITAIN:UNITED KINGDOM

In specific cases, questions such as below can be asked:

/WHAT IS THE DEFINITION OF LIBERIAN SHIP?
 LIBERIAN SHIP:SHIP WHOSE FLAG IS LIBERIA
 /WHAT IS THE DEFINITION OF SUPERSHIP?
 SUPERSHIP:SHIP WHOSE LENGTH IS GREATER THAN 900

In cases where items were defined ambiguously, the answers reflect this, as was done in the case of SUPERSHIP. It will be noticed that two ways are available for making the inquiry:

WHAT IS THE DEFINITION OF . . . ?

WHAT ARE THE DEFINITIONS OF . . . ?

```

>WHAT 'IS 'THE 'DEFINITION 'OF 'SUPERSHIP?
'AMBIGUOUS:
'(01)'
'SUPERSHIP:SHIP 'WHOSE 'ENDURANCE 'IS 'GREATER 'THAN '160
'(02)'
'SUPERSHIP:SHIP 'WHOSE 'LENGTH 'IS 'GREATER 'THAN '900
>WHAT 'ARE 'THE 'DEFINITIONS 'OF 'SUPERSHIP?
'AMBIGUOUS:
'(01)'
'SUPERSHIP:SHIP 'WHOSE 'ENDURANCE 'IS 'GREATER 'THAN '160
'(02)'
'SUPERSHIP:SHIP 'WHOSE 'LENGTH 'IS 'GREATER 'THAN '900

```

One important point about definitions involving variables is that one need not know the specific items involved in a given definition in order to get at it. If, for instance, the user wants to find out about the definition of STATIONED but does not know (or remember) the variables which were used in defining it, he may use any items which are of the same character as the variables in the definition. Thus, as illustrated in the first example below, any numbers can be used in definitions involving number variables. In cases of definitions involving nouns, any nouns can be used, as shown in the second example.

```

>WHAT 'IS 'THE 'DEFINITION 'OF 'F(8,"9")?
'F(8,"9"):"8"♦"8"+"9"♦"9"
>WHAT 'IS 'THE 'DEFINITION 'OF 'F(3,4)?
'F(8,"9"):"8"♦"8"+"9"♦"9"
>WHAT 'IS 'THE 'DEFINITION 'OF 'NEW 'YORK 'STATIONED 'SUBMARINE?
'"NORFOLK" 'STATIONED '"SHIP":'"SHIP" 'WHOSE 'HOME 'PORT 'IS '"NORFOLK"

```

b. Deleting Definitions

Definitions can be deleted in a simple manner, as shown in the sequence below.

```

WHAT IS THE DEFINITION OF CHILD?
CHILD:CONVERSE OF PARENT
>DELETE THE DEFINITION OF CHILD.
DEFINITION DELETED.
>WHAT IS THE DEFINITION OF CHILD?
NO DEFINITIONS FOUND.
>WHAT IS THE DEFINITION OF GRANDFATHER?
GRANDFATHER:FATHER OF FATHER
>DELETE THE DEFINITION OF GRANDFATHER.
DEFINITION DELETED.

```

In cases of definitions involving variables, the values of the variables need not be known in order to delete a given definition, as illustrated in the following protocol.

```

XHOW 'MANY '10K 'SHIPS 'ARE 'THERE?
  '116
XWHAT 'IS 'THE 'DEFINITION 'OF '2K 'SHIP?
  "'2"K 'SHIP:SHIP 'WHOSE 'MAXIMUM 'CRUISING 'RANGE 'IS 'GREATER 'THAN "'2"♦1000
XDELETE 'THE 'DEFINITION 'OF '2K 'SHIP.'
  'DEFINITION 'DELETED.'
XWHAT 'IS 'THE 'DEFINITION 'OF '2K 'SHIP?
  'NO 'DEFINITIONS 'FOUND.'
XHOW 'MANY '10K 'SHIPS 'ARE 'THERE?
  'ONE 'OF 'THE 'PHRASES 'IS 'NOT 'DEFINED 'ANY 'MORE.'

```

The next protocol shows how the deletion of a definition is propagated.

```

XDEF:G("'4"):F("'4",0)+"4"
  ' 'DEFINED.'
XWHAT 'IS 'G(10)?
  '110
XWHAT 'IS 'THE 'DEFINITION 'OF 'F(3,4)?
  'F("'8", "'9"): "'8"♦"'8"♦"'9"♦"'9"
XDELETE 'THE 'DEFINITION 'OF 'F(3,4).'
  'DEFINITION 'DELETED.'
XWHAT 'IS 'F(3,4)?
  'ONE 'OF 'THE 'PHRASES 'IS 'NOT 'DEFINED 'ANY 'MORE.'
XWHAT 'IS 'G(19)?
  'ONE 'OF 'THE 'PHRASES 'IS 'NOT 'DEFINED 'ANY 'MORE.'
XDEF:F("'8", "'9"): "'8"♦"'9"
  ' 'DEFINED.'
XWHAT 'IS 'G(10)?
  '20

```

In cases of ambiguous definitions, either one can be deleted, or both, as the protocols below illustrate. The wordings that can be used are:

```

DELETE DEFINITION 2 OF . . .
DELETE THE SECOND DEFINITION OF . . .
DELETE ALL DEFINITIONS OF . . .
DELETE THE DEFINITION OF . . .

```

>WHAT IS THE DEFINITION OF SUPERSHIP?
 'AMBIGUOUS:
 '(01)
 'SUPERSHIP:SHIP WHOSE ENDURANCE IS GREATER THAN 160
 '(02)
 'SUPERSHIP:SHIP WHOSE LENGTH IS GREATER THAN 900
 >DELETE DEFINITION 2 OF SUPERSHIP.
 'DEFINITION DELETED.
 >DEF:GRANDFATHER:FATHER OF FATHER
 DEFINED.
 >DEF:GRANDFATHER:MALE PARENT OF FATHER
 DEFINED.
 >WHAT IS THE DEFINITION OF GRANDFATHER?
 AMBIGUOUS:
 (01)
 GRANDFATHER:MALE PARENT OF FATHER
 (02)
 GRANDFATHER:FATHER OF FATHER
 >DELETE THE SECOND DEFINITION OF GRANDFATHER.
 DEFINITION DELETED.
 >DELETE ALL DEFINITIONS OF GRANDFATHER.
 DEFINITION DELETED.
 >WHAT IS THE DEFINITION OF GRANDFATHER?
 NO DEFINITIONS FOUND.

c. Changing Definitions

Changing a definition can be achieved by deleting the existing one and substituting a new one for it, as shown in the following protocol.

>WHAT IS THE DEFINITION OF SUPERSHIP?
 'SUPERSHIP:SHIP WHOSE ENDURANCE IS GREATER THAN 160
 >DELETE THE DEFINITION OF SUPERSHIP.
 'DEFINITION DELETED.
 >DEF:SUPERSHIP:SHIP WHOSE LENGTH IS GREATER THAN 900
 'DEFINED.
 >WHAT IS THE DEFINITION OF SUPERSHIP?
 'SUPERSHIP:SHIP WHOSE LENGTH IS GREATER THAN 900
 >WHAT IS THE LENGTH AND ENDURANCE OF EACH SUPERSHIP?
 'CONSTELLATION ' '1072 '45
 'SARATOGA ' '1039 '45
 'AMERICA ' '1072 '45
 'KITTYHAWK ' '1072 '45
 'JOHN F. KENNEDY '1072 '45
 'INDEPENDENCE ' '1039 '45
 'KIEV ' '925 '60
 'MINSK ' '925 '60

D. DELETING VOCABULARY ITEMS

Words for individuals (names), classes, relations, and number relations which have been introduced as primitive items can be deleted, as illustrated below.

```

CDR H. HOCKETT:=NAME
DEFINED.
>DELETE VOCABULARY ITEM CDR H. HOCKETT.
VOCABULARY ITEM HAS BEEN DELETED.
>TASK SHIP:=CLASS
DEFINED.
>DELETE VOCABULARY ITEM TASK SHIP.
VOCABULARY ITEM HAS BEEN DELETED.
>FIRE SUPPORT:=RELATION
DEFINED.
>DELETE VOCABULARY ITEM FIRE SUPPORT.
VOCABULARY ITEM HAS BEEN DELETED.
>FIRE POWER:=NUMBER RELATION
DEFINED.
>DELETE VOCABULARY ITEM FIRE POWER.
VOCABULARY ITEM HAS BEEN DELETED.

```

In cases, however, where data has been introduced about the vocabulary items, this data must be deleted before the vocabulary item itself can be deleted. As the following protocol shows, the user is given help in accomplishing this task.

```

>IMPORTANT 'SHIP':=CLASS
'DEFINED.'
>THE 'KITTYHAWK' AND 'JOHN F.' 'KENNEDY' ARE 'IMPORTANT 'SHIPS.'
'DATA 'HAS 'BEEN 'ADDED.'
>RATING:=NUMBER 'RELATION
'DEFINED.'
>THE 'RATING 'OF 'EACH 'IMPORTANT 'SHIP 'IS '84.'
'DATA 'HAS 'BEEN 'ADDED.'
>DELETE 'VOCABULARY 'ITEM 'IMPORTANT 'SHIP.'
'DATA 'MUST 'FIRST 'BE 'DELETED.'
'MEMBERS 'AND 'MEMBERS 'OF 'SUBCLASSES 'ARE:'
'KITTYHAWK
'JOHN 'F.' 'KENNEDY
>KITTYHAWK 'AND 'JOHN 'F.' 'KENNEDY 'ARE 'NOT 'IMPORTANT 'SHIPS.'
'DATA 'HAS 'BEEN 'DELETED.'
>DELETE 'VOCABULARY 'ITEM 'IMPORTANT 'SHIP.'
'VOCABULARY 'ITEM 'HAS 'BEEN 'DELETED.'

```

>DELETE 'VOCABULARY 'ITEM 'RATING.'
'DATA 'MUST 'FIRST 'BE 'DELETED.'
'RELATED 'PAIRS 'ARE:
'KITTYHAWK '84
'JOHN 'F.' 'KENNEDY ' '84
>THE 'RATING 'OF 'EACH 'IMPORTANT 'SHIP 'IS 'NOT '84.'
'EH?
>THE 'RATING 'OF 'THE 'KITTYHAWK 'IS 'NOT '84.'
'DATA 'HAS 'BEEN 'DELETED.'
>THE 'RATING 'OF 'THE 'JOHN 'F.' 'KENNEDY 'IS 'NOT '84.'
'DATA 'HAS 'BEEN 'DELETED.'
>DELETE 'VOCABULARY 'ITEM 'RATING.'
'VOCABULARY 'ITEM 'HAS 'BEEN 'DELETED.'

IV. VERSIONS IN THE REL SYSTEM

The architecture of the REL system is oriented towards giving the user as much flexibility as possible in working with his data, as evidenced in the preceding section on modifications, extensions, and definitions. If those capabilities are to be indeed useful, however, the user cannot be limited to one copy of a given data base, since that would soon be changed by the user in a number of ways, some of which he might not want to be permanent. This consideration led to the development of a system organization that allows the user to have two (or more) copies of his data -- one that he works with, thus changing it, and another that he keeps as a backup. Those copies are called versions.

A. THE NATURE OF A VERSION

There are two kinds of versions:

- (1) User's versions
- (2) Base versions

A-1. USER'S VERSIONS

A user's version is a language-data base package, that is it incorporates the grammar and processing routines of a particular REL language and a user's data base. Any changes, extensions, and definitions that the user introduces into it become part of it permanently. Versions, unless they are deleted, are automatically retained from session to session. An REL system at a given installation may thus contain a number of versions belonging to a number of users. This is an important consideration from the point of view of space.

Typically, a given user will want to have at least two versions for two reasons. One version would be a permanent, backup version which could not be modified either by the user himself or by

anybody else. The other version would at a certain initial point be an exact copy of the permanent version, but soon after would most likely undergo changes, through extensions and definitions. This working version is the one in which the user will also experiment with definitions and data analyses in order, for instance, to find a most suitable definition or alternate conclusions in data analyses. Once the user is satisfied with the modifications and extensions they can be incorporated into the permanent backup version by replacing it, through deleting and copying, with the working version.

That is one reason for having two versions. Another is that things can go wrong -- for instance through hitting a bug. Although this is highly unlikely, the working version may become unreliable or even unusable. It should then be deleted, and a fresh copy made of the backup version. The new copy will not, of course, contain any of the modifications or extensions introduced by the user. To avoid this, a user may make copies of the working versions as he goes along, but limitations of space may, of course, be a consideration.

A-2. BASE VERSIONS

A base version may have the same characteristics as a user's permanent version, but it may also be different and consist only of a given language and contain no data. Base versions are supplied by the system. One of the principal REL languages is REL English. It constitutes a base version which contains only the grammar rules and a corresponding set of interpretive semantic routines. It does not contain any data base, and hence vocabulary, except such grammatical words as WHAT, WHO, HOW MANY, EACH, EQUAL TO, BEFORE, AND, TWO, names of months (e.g. JANUARY), and the like which are part of the grammar rules.

B. THE VERSIONS IN THIS DEMONSTRATION SYSTEM

The versions currently available in the demonstration system are:

- (1) NAVY
- (2) NAVY-1

These two versions are identical, but there is a difference in their status, that is what can be done with them (see section on status of versions). These versions contain the REL English language and the Navy data base described in reference 1.

- (3) COMAIR

This version contains the REL English language and a data base on U.S. commercial aircraft.

- (4) REL ENGLISH

This version is a base version (see section on the nature of versions). It contains the REL English language but no data.

C. WORKING WITH VERSIONS

There is a body of commands in the REL system that are used for the manipulation of versions. They constitute part of the command language which is fully described in Reference 2. Some commands are as follows.

C-1. COPY <version name 2> FROM <version name 1>

```
>COPY NAVY-2 FROM NAVY
VERSION HAS BEEN COPIED
>COPY COMAIR-1 FROM COMAIR
VERSION HAS BEEN COPIED
```

This command makes a copy of an already existing version. The new version is identical to the one of which it is a copy. The new version can be used and altered without in any way disturbing the version of which it is a copy.

The name of the new version may be any characters, including blanks, up to twenty (20) in length, but it may not be a name that has already been used for some other version.

```
>COPY COMAIR-1 FROM COMAIR
NEW VERSION NAME IS ALREADY IN USE
>COPY NAVY FROM REL ENGLISH
NEW VERSION NAME IS ALREADY IN USE
```

Thus, if a copy of the NAVY version is made it cannot be called NAVY-1 since such a version already exists (see section on current versions). The user who makes a copy with a new name is considered the creator of this new version (see section on status of versions).

The result of the command

```
>COPY ARPA PROJECTS FROM REL ENGLISH
VERSION HAS BEEN COPIED
```

is a version containing nothing but REL English. A user can start building the data base into this new version named ARPA PROJECTS by entering data (see section on adding data items).

C-2. ENTER <version name>

In order to use a version, one that has been around for a while or a newly copied one, the user must ENTER it, as in the examples below:

```
>ENTER COMAIR-1
PROCEED.
>ENTER ARPA PROJECTS
PROCEED.
```

Clearly, only a version which is ENTERABLE can be entered (see section on status of versions). After the ENTER command is executed, the user is already in his version and his statements thereafter are interpreted in the language of a given version until he exits from the given version.

C-3. EXIT

This command is the way to get out of a given version. If a user is in a version and types EXIT, the system responds:

```
EXIT
COMMAND LANGUAGE, PROCEED
```

At that time the user may make use of any of the other commands, for example, copy another version or delete a version. If, however, he wants to terminate the session, it is necessary to type EXIT again. Thus the sequence from entering a version to getting out of the REL system entirely is:

```
>ENTER COMAIR-1
PROCEED.
>HOW MANY AIRCRAFT ARE THERE?
78

>EXIT
COMMAND LANGUAGE, PROCEED
>EXIT
PROCESSING COMPLETED, THANK YOU.
READY
```

C-4. DELETE <version name>

This command completely erases the version specified. Only the creator of a version can delete a version (or a system administrator, if such a person has been designated).

The disk space (extents) occupied by a given version is released back to the system when a given version is deleted. This is important to remember upon the appearance of the message:

UNABLE TO ALLOCATE ADDITIONAL EXTENTS

In such a case, some version that can be spared should be deleted, for example:

DELETE NAVY-2

The following protocol illustrates such manipulations. It will be noticed that in the DIRECTORY two versions appear, SYSTEM and COMMAND, which are system versions. SYSTEM cannot be entered by users. COMMAND is automatically entered when logging on or exiting from a user version.

```

>DIRECTORY
USER ID  VERSION NAME  EXTENTS  ENTERABLE  COPYABLE
.....
TOTAL                210
ALLOCATED            210

RELSYS  COMAIR-1      37  CREATOR  CREATOR
        ARPA PROJECTS 33  CREATOR  CREATOR
        COMAIR        37  NO ONE   ANYONE
        NAVY          66  NO ONE   ANYONE
        REL ENGLISH   27  NO ONE   ANYONE
        SYSTEM        7  CREATOR  CREATOR
        COMMAND       3  CREATOR  CREATOR

>COPY NAVY-1 FROM NAVY
NOT ENOUGH ROOM FOR NEW VERSION
>ENTER COMAIR-1
PROCEED.
>DEF:SPECIAL AIRCRAFT:AIRCRAFT WHOSE TAKEOFF LENGTH\
>IS LESS THAN 4500 AND THAT HAVE LANDING SPEED\
>LESS THAN 100
DEFINED.

```

>LIST THE TAKEOFF LENGTH AND LANDING SPEED OF EACH
>SPECIAL AIRCRAFT.

SYSTEM ERROR AT (UTYB6 ***07A)

UNABLE TO ALLOCATE ADDITIONAL EXTENTS.

SENTENCE ABNORMALLY TERMINATED. VERSION MAY
HAVE BEEN ERRONEOUSLY MODIFIED. PROCEED.

>EXIT

COMMAND LANGUAGE, PROCEED

>DELETE COMAIR-1

VERSION HAS BEEN DELETED.

>DELETE ARPA PROJECTS

VERSION HAS BEEN DELETED.

>COPY NAVY-1 FROM NAVY

VERSION HAS BEEN COPIED

>DIRECTORY

USER ID	VERSION NAME	EXTENTS	ENTERABLE	COPYABLE
	TOTAL	210		
	ALLOCATED	205		
RELSYS	NAVY-1	65	CREATOR	CREATOR
	COMAIR	37	NO ONE	ANYONE
	NAVY	66	NO ONE	ANYONE
	REL ENGLISH	27	NO ONE	ANYONE
	SYSTEM	7	CREATOR	CREATOR
	COMMAND	3	CREATOR	CREATOR

D. STATUS OF VERSIONS

The status of a version determines:

- (1) Who can enter the version
- (2) Who can copy the version

The status can be changed only by the creator of a version. The commands which are available to the creator for this purpose are described in Reference 2, and one is illustrated in the middle of the following protocol. When a version is created, its initial status is that it can be copied and entered only by the creator.

There are three cases with respect to the status of a version. It may be copyable or enterable by:

- (1) Anyone
- (2) No one
- (3) Creator

Since these properties are independent, there are thus nine possibilities. NAVY, COMAIR, and REL ENGLISH are copyable by anyone and enterable by no one. It is thus possible to:

COPY NAVY-2 FROM NAVY

but it is not possible to:

ENTER NAVY

NAVY-1 is copyable by creator and enterable by creator only. The creator can thus:

COPY NAVY-3 FROM NAVY-1

ENTER NAVY-1

ENTER NAVY-3

DELETE NAVY-1

DELETE NAVY-3

The status of existing versions and the amount of storage they occupy can be found out from the director through the command:

DIRECTORY

as is illustrated below.

```
>DIRECTORY
USER ID  VERSION NAME  EXTENTS  ENTERABLE  COPYABLE
.....
TOTAL          210
ALLOCATED      140

RELSYS  COMAIR          37  NO ONE  ANYONE
        NAVY           66  NO ONE  ANYONE
        REL ENGLISH    27  NO ONE  ANYONE
        SYSTEM          7  CREATOR  CREATOR
        COMMAND         3  CREATOR  CREATOR
>ENTER COMAIR
VERSION CAN NOT BE ENTERED
>COPY COMAIR-1 FROM COMAIR
VERSION HAS BEEN COPIED
>DIRECTORY
USER ID  VERSION NAME  EXTENTS  ENTERABLE  COPYABLE
.....
TOTAL          210
ALLOCATED      177

RELSYS  COMAIR-1        37  CREATOR  CREATOR
        COMAIR          37  NO ONE  ANYONE
        NAVY           66  NO ONE  ANYONE
        REL ENGLISH    27  NO ONE  ANYONE
        SYSTEM          7  CREATOR  CREATOR
        COMMAND         3  CREATOR  CREATOR
>MARK COMAIR-1 COPYABLE BY NO ONE
VERSION HAS BEEN MARKED
>DIRECTORY
USER ID  VERSION NAME  EXTENTS  ENTERABLE  COPYABLE
.....
TOTAL          210
ALLOCATED      177

RELSYS  COMAIR-1        37  CREATOR  NO ONE
        COMAIR          37  NO ONE  ANYONE
        NAVY           66  NO ONE  ANYONE
        REL ENGLISH    27  NO ONE  ANYONE
        SYSTEM          7  CREATOR  CREATOR
        COMMAND         3  CREATOR  CREATOR
>COPY TEST FROM COMAIR-1
VERSION MAY NOT BE COPIED
>ENTER COMAIR-1
PROCEED.
>HOW MANY AIRCRAFT ARE THERE?
78
>EXIT
COMMAND LANGUAGE, PROCEED
```

V. QUERYING AN UNKNOWN DATA BASE

A data base that is not known to a user can be approached through a number of general questions, which are aimed at revealing the underlying structures of the data base and their contents, as well as definitions which may have been introduced.

For the purpose of this illustration it is assumed that a version called COMAIR contains such an unknown data base.

We can inquire about the structural organization of the data with questions about what classes and relations it contains. Information about what is known about specific individuals and classes can also be obtained. Another group of questions pertains to definitions which may have been introduced.

To find out what CLASSES are in the data base, one can ask any one of the following questions:

WHAT ARE CLASSES?

WHAT ARE THE CLASSES?

WHAT CLASSES EXIST?

WHAT CLASSES ARE THERE?

```

>WHAT ARE CLASSES?
  AIRCRAFT
  PASSENGER PLANE
  CARGO PLANE
>WHAT ARE THE CLASSES?
  AIRCRAFT
  PASSENGER PLANE
  CARGO PLANE
>WHAT CLASSES EXIST?
  AIRCRAFT
  PASSENGER PLANE
  CARGO PLANE
>WHAT CLASSES ARE THERE?
  AIRCRAFT
  PASSENGER PLANE
  CARGO PLANE

```

To obtain information about RELATIONS, one should similarly ask:

WHAT ARE RELATIONS?
 WHAT ARE THE RELATIONS?
 WHAT RELATIONS EXIST?
 WHAT RELATIONS ARE THERE?

>WHAT ARE RELATIONS?
 THERE ARE 41 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
 RESPOND WITH "ALL", "NONE", OR A NUMBER.
 >ALL
 MANUFACTURER
 MODEL
 POPULAR NAME
 SERIES DESIGNATION
 MISSION
 CREW SIZE
 MAX PASSENGERS
 SEATING CAPACITY
 CARGO CAPACITY
 CARGO SPACE
 WINGSPAN
 MAX LENGTH
 MAX HEIGHT
 EMPTY WEIGHT
 GROSS WEIGHT
 MAX LANDING WEIGHT
 NUMBER OF ENGINES
 ENGINE MAKE
 ENGINE MODEL
 ENGINE DESIGNATION
 MAX SPEED
 MAX MACH SPEED
 OPT CRUISE SPEED
 OPT CRUISE MACH SPEED
 LANDING SPEED
 CONDITIONAL LANDING SPEED
 TAKEOFF LENGTH
 CONDITIONAL TAKEOFF LENGTH
 LANDING LENGTH
 CONDITIONAL LANDING LENGTH
 STILL AIR RANGE
 CONDITIONAL STILL AIR RANGE
 CONDITION 1
 CONDITION 2
 CONDITION 3
 CONDITION 4
 CONDITION 5
 2ND ENGINE MODEL
 2ND ENGINE DESIGNATION
 3RD ENGINE MODEL
 3RD ENGINE DESIGNATION

```

>WHAT RELATIONS EXIST?
THERE ARE 41 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
RESPOND WITH "ALL", "NONE", OR A NUMBER.
>2
MANUFACTURER
MODEL
>WHAT RELATIONS ARE THERE?
THERE ARE 41 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
RESPOND WITH "ALL", "NONE", OR A NUMBER.
>2
MANUFACTURER
MODEL

```

Some such questions can clearly have very long answers in case of large data bases. As an aid, the computer tells the user how many lines of output there are and gives the option of selecting as many as are wanted, or all, or none.

To find out if there are any DEFINITIONS and what they are, one can ask:

```

WHAT ARE DEFINITIONS?
WHAT ARE THE DEFINITIONS?
WHAT HAS BEEN DEFINED?
WHAT DEFINITIONS ARE THERE?

```

The following sequence illustrates a situation in which at first there are no definitions in the version.

```

>WHAT ARE DEFINITIONS?
NONE
>DEF: AIRPLANE: AIRCRAFT
DEFINED.
>DEF: PAYLOAD: GROSS WEIGHT - EMPTY WEIGHT
DEFINED.
>DEF: RANGE: STILL AIR RANGE
DEFINED.
>DEF: LONG RANGE AIRCRAFT: AIRCRAFT WHOSE RANGE EXCEEDS 7000
DEFINED.
>WHAT ARE DEFINITIONS?
AIRPLANE: AIRCRAFT
PAYLOAD: GROSS WEIGHT - EMPTY WEIGHT
RANGE: STILL AIR RANGE
LONG RANGE AIRCRAFT: AIRCRAFT WHOSE RANGE EXCEEDS 7000
>WHAT HAS BEEN DEFINED?
AIRPLANE: AIRCRAFT
PAYLOAD: GROSS WEIGHT - EMPTY WEIGHT
RANGE: STILL AIR RANGE
LONG RANGE AIRCRAFT: AIRCRAFT WHOSE RANGE EXCEEDS 7000
>WHAT DEFINITIONS ARE THERE?
AIRPLANE: AIRCRAFT
PAYLOAD: GROSS WEIGHT - EMPTY WEIGHT
RANGE: STILL AIR RANGE
LONG RANGE AIRCRAFT: AIRCRAFT WHOSE RANGE EXCEEDS 7000

```


The information contained in the data base about INDIVIDUALS and CLASSES can be obtained through three equivalent phrases:

WHAT IS KNOWN ABOUT . . . ?

WHAT DO YOU KNOW ABOUT . . . ?

DESCRIBE. . . .

Thus, if we have the class of AIRCRAFT, we can ask:

WHAT IS KNOWN ABOUT AIRCRAFT?

```
>WHAT IS KNOWN ABOUT AIRCRAFT?
THERE ARE 39 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
RESPOND WITH "ALL", "NONE", OR A NUMBER.
>ALL
ALL ARE AIRCRAFT
ALL HAVE 3RD ENGINE DESIGNATION
        3RD ENGINE MODEL
        2ND ENGINE DESIGNATION
        2ND ENGINE MODEL
        CONDITION 5
        CONDITION 4
        CONDITION 3
        CONDITION 2
        CONDITION 1
        ENGINE DESIGNATION
        ENGINE MODEL
        ENGINE MAKE
        GROSS WEIGHT
        MAX HEIGHT
        MAX LENGTH
        WINGSPAN
        SERIES DESIGNATION
        POPULAR NAME
        MODEL
        MANUFACTURER
SOME ARE CARGO PLANE
        PASSENGER PLANE
SOME HAVE MAX LANDING WEIGHT
        LANDING LENGTH
        MAX PASSENGERS
        EMPTY WEIGHT
        LANDING SPEED
        MISSION
        MAX SPEED
        STILL AIR RANGE
        CREW SIZE
        CARGO CAPACITY
        CARGO SPACE
        TAKEOFF LENGTH
        NUMBER OF ENGINES
        OPT CRUISE MACH SPEED
        OPT CRUISE SPEED
        SEATING CAPACITY
```


In the case of individuals, say, the BOEING 720, one can similarly ask:

WHAT IS KNOWN ABOUT BOEING 720?

>WHAT IS KNOWN ABOUT THE BOEING 720?

THERE ARE 36 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
RESPOND WITH "ALL", "NONE", OR A NUMBER.

>ALL

IS A PASSENGER PLANE
AIRCRAFT
HAS A 3RD ENGINE DESIGNATION
3RD ENGINE MODEL
2ND ENGINE DESIGNATION
2ND ENGINE MODEL
CONDITION 5
CONDITION 4
CONDITION 3
CONDITION 2
CONDITION 1
STILL AIR RANGE
LANDING LENGTH
TAKEOFF LENGTH
LANDING SPEED
OPT CRUISE MACH SPEED
MAX SPEED
ENGINE DESIGNATION
ENGINE MODEL
ENGINE MAKE
NUMBER OF ENGINES
MAX LANDING WEIGHT
GROSS WEIGHT
EMPTY WEIGHT
MAX HEIGHT
MAX LENGTH
WINGSPAN
CARGO CAPACITY
SEATING CAPACITY
MAX PASSENGERS
CREW SIZE
MISSION
SERIES DESIGNATION
POPULAR NAME
MODEL
MANUFACTURER

>WHAT DO YOU KNOW ABOUT THE BOEING 720?
 THERE ARE 36 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
 RESPOND WITH "ALL", "NONE", OR A NUMBER.
 >2
 IS A PASSENGER PLANE
 AIRCRAFT
 >DESCRIBE THE BOEING 720.
 THERE ARE 36 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
 RESPOND WITH "ALL", "NONE", OR A NUMBER.
 >2
 IS A PASSENGER PLANE
 AIRCRAFT

One can also ask specific questions about existing classes or relations,
 such as:

WHAT AIRCRAFT ARE THERE?
 THERE ARE 78 LINES IN THIS ANSWER. HOW MANY DO YOU WANT?
 RESPOND WITH "ALL", "NONE", OR A NUMBER.
 >10
 BOEING 707-320C INTERCONTINENTAL
 BOEING 720
 BOEING 707-420 INTERCONTINENTAL
 BEECH B-99
 BOEING 707-120
 BOEING 707-120B
 BOEING 707-320B INTERCONTINENTAL
 BOEING 707-320 INTERCONTINENTAL
 BOEING 720B
 BOEING 727-200 ADVANCED
 >WHAT ARE MANUFACTURERS?
 BOEING
 BEECH
 MCDONNELL DOUGLAS
 FAIRCHILD INDUSTRIES
 GENERAL DYNAMICS/CONVAIR
 LOCKHEED

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